Public Health Assessment for

0493

NEWPORT NAVAL EDUCATION/TRAINING CENTER
MIDDLETOWN, NEWPORT COUNTY, RHODE ISLAND
CERCLIS NO. RI6170085470
MAY 21, 1993

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

Comment Period Ends:

JUNE 25, 1993

PUBLIC HEALTH ASSESSMENT

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FEDERAL PROGRAMS BRANCH
DIVISION OF HEALTH ASSESSMENT AND CONSULTATION
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations 42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the Agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited timeframe. To the extent possible, it presents an assessment of the potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR. This revised document has now been released for a 30 day public comment period. Subsequent to the public comment period, ATSDR will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

Comments regarding this report are welcome. Please address to:

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ATSDR AND THE PUBLIC HEALTH ASSESSMENT PROCESS AT DEPARTMENT OF DEFENSE FACILITIES

The Agency for Toxic Substances and Disease Registry (ATSDR) is part of the U.S. Public Health Service. ATSDR's mission is to prevent or mitigate adverse human health effects and diminished quality of life resulting from exposure to hazardous substances in the environment. ATSDR has no regulatory authority, but does recommend public health actions that address potential adverse health effects resulting from environmental releases from hazardous waste sites.

The public health assessment is the cornerstone ATSDR uses to address public health issues. The document discusses available information about site-related hazardous substances and evaluates whether exposure to them -- in the past, present, or future -- might cause adverse health effects in members of the community.

ATSDR is responsible for preparing public health assessments according to the Comprehensive Environmental Response Compensation and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6). As mandated by that law, ATSDR conducts public health assessments of hazardous waste sites listed or proposed for listing on the U.S. Environmental Protection Agency's (EPA) National Priorities List (NPL). ATSDR also responds to requests (petitions) to conduct public health assessments.

Three primary sources of information are used in a public health assessment: environmental data, community health concerns, and health outcome data. ATSDR does not routinely perform environmental sampling. The environmental data used in public health assessments are provided by the Department of Defense (DOD) component involved; EPA, state, and local environmental and health agencies; and other groups or individuals. In addition, ATSDR health assessors conduct site visits to observe firsthand current conditions at the site, land use, public accessibility, and demographic characteristics of the nearby community.

Concerns the community has about health are gathered to determine if specific health effects are being experienced by people who live or work near the site. Information from the public also helps ATSDR determine how people may have been or might be exposed to hazardous substances in the environment. Throughout the public health assessment process, ATSDR staff members talk with people living or working at or near the site about their site-related health concerns. Other sources of community health concerns are records from the installation's Public Affairs Office, EPA's Community Relations representative, and state and local health and environmental agencies.

Health outcome databases document health effects that occur in populations. Those data, which come from sources such as state tumor registry databases, birth defects databases, vital statistics records, or other records, may provide information about the general health of the community living near a site. Other more specific records, such as hospital and medical records and records from site-specific health studies, may be used.
Demographic data that provide information on population characteristics (e.g., age, sex, socioeconomic status) are used when analyzing health outcome data.

ATSDR identifies actual and perceived site-related health effects and the level of public health hazard posed by the site. ATSDR then makes recommendations to the appropriate DOD components, EPA, and relevant state and local agencies on preventing or alleviating human exposures to site-related contaminants. When indicated, ATSDR identifies a need for any follow-up health activities -- such as epidemiologic studies, registries or community health education. Finally, ATSDR provides a mechanism to re-evaluate health issues as site conditions change (e.g., after site remediation or changes in land use) or when new data or information are available.

A public health action plan (PHAP) is included in the public health assessment. It contains a description of actions ATSDR and other parties will take at and in the vicinity of the site. The purpose of the PHAP is to provide a plan of action for preventing and mitigating adverse human health effects resulting from exposure to hazardous substances in the environment. ATSDR annually monitors the implementation of the plan. Public health actions may include, but are not limited to, restricting site access, sampling, surveillance, registries, health studies, environmental health education, and applied substance-specific research.

Public health assessments are distributed in three phases: an initial release (red cover), a public comment release (brown cover), and a final release (blue cover). The initial release document, which is prepared as part of the process of gathering, analyzing, and drawing conclusions and recommendations from the vast amount of information evaluated in a public health assessment, is provided for review and comment to the DOD component involved, EPA, and state and local environmental and health agencies. This release gives agencies the opportunity to comment on the completeness of information they have provided and the clarity of the presentation. The initial release comment period lasts 45 days. Following the initial release, ATSDR prepares the document for distribution to the general public. The public is notified of the document's availability at repositories (e.g., libraries, city hall) in the site area through advertisements and public notices in newspapers. The comment period lasts 30 days. ATSDR addresses all public comments and revises or appends the document as appropriate. The final public health assessment is then released; that document includes written responses to all public comments.

A public health assessment is an ongoing process. ATSDR revises final documents if new information about the environment, community health concerns, and health outcome data becomes available and is found to modify previous conclusions and recommendations. For more information about the ATSDR public health assessment process and related programs please write to:

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SUMMARY

The Agency for Toxic Substances and Disease Registry (ATSDR) has concluded that the Naval Education and Training Center (NETC) is an indeterminate public health hazard (see Appendix A for definition of categories). Potential adverse health effects associated with contaminants found at NETC cannot be fully evaluated. More sampling and analysis are needed to completely assess the site; ATSDR recommends additional sampling at the Old Fire Fighting Training Area to further characterize the exposure potential. Sampling of shellfish and mussels is recommended to characterize potential contamination of biota.

NETC has been an active naval facility since 1869. NETC extends along the western shore of Aquidneck Island and lies within portions of Newport, Middletown, and Portsmouth, Rhode Island. Activities at the Newport naval complex have included fueling of destroyers and cruisers, torpedo development, and training.

NETC was placed on the National Priorities List (NPL) on November 21, 1989. Five areas at NETC are being investigated under the remedial investigation/feasibility study: McAllister Point Landfill, Melville North Landfill, Tank Farm Four, Tank Farm Five, and the Old Fire Fighting Training Area. The Melville North Landfill site was sold prior to NETC becoming an NPL listing and is not currently within the scope of U.S. Environmental Protection Agency's (EPA) oversite and approval authority. However, ATSDR has evaluated this landfill for its public health significance and Melville North Landfill is included in this public health assessment.

Contaminants of concern have been detected in groundwater, surface soil, subsurface soil, and sediment at NETC. Completed pathways of past, present, and future exposure to contaminated surface soil have been identified at the Old Fire Fighting Training Area. Contaminants of concern in that area include metals, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs). The Old Fire Fighting Training Area is the site of a children's day care center, a picnic area, a playground, and a ballfield.

Potential pathways of exposure to contaminated surface soil and sediment were identified. In addition, there could be future exposure to contaminated groundwater and subsurface soil in areas, such as Melville North Landfill, that are scheduled for development. The food chain is also a potentially complete pathway. The extent of contamination of shellfish must be further characterized before the health implications of exposure to those potential pathways can be evaluated. Contaminants of concern identified in the potential pathways include metals, PAHs, PCBs, volatile organic compounds, and pesticides.

The community is concerned about contamination of drinking water sources in the area. Because those sources are upgradient of the contamination detected at NETC, and groundwater flow is toward Narragansett Bay, contamination of current drinking water sources is not expected. However, groundwater from any of the study areas should not be developed into a drinking water source.

The community also expressed concern about cancer incidence in former landfill workers. Cancer rates in the NETC area are similar to cancer rates for the state of Rhode Island, based on local census tract vital statistics.

The ATSDR Health Activities Recommendation Panel (HARP) has evaluated the data and information in this public health assessment and determined that health education of the workers at the childrens day care center is indicated. The Public Health Action Plan defines the implementation of the health education.

BACKGROUND

A. Site Description and History

Information discussed in this section was taken from three documents prepared by Navy contractors the Remedial Investigation Technical Report (Volume I), the Initial Assessment Study of the Naval Education and Training Center, Newport, RI, and the Confirmation Study Report on Hazardous Waste Sites at Naval Education and Training Center, Newport, RI (1,2,3).

The Naval Education Training Center (NETC) is in Newport County, Rhode Island; parts of the installation are in the municipalities of Newport, Middletown, and Portsmouth, Rhode Island. The site, which is about 1,063 acres in size, is approximately 60 miles south of Boston and 25 miles southeast of Providence. The installation layout is long and narrow; it follows the shoreline of Aquidneck Island and borders Narragansett Bay for nearly 6 miles (1). A site location map is provided in Figure 1 (Appendix A).

The Navy's first permanent activity in Newport was in 1869, when the experimental Torpedo Station at Goat Island was established. In 1881, Coasters Harbor Island was acquired by the Navy and used for training purposes. In 1884, the Naval War College was established on the Coaster's Harbor Island.

World War I significantly increased military activity at Newport. During the war, destroyers and cruisers were fueled by the Melville coal depot and fuel tanks. The installation's role as a fueling facility and the torpedo development program were expanded during the late 1930s.

Following World War II, activities at Newport reflected the peace-time status, and, in 1946, the entire naval complex was consolidated into a single naval command. In 1951, the Torpedo Station was permanently deactivated. Naval forces in the Newport area were reorganized in 1974; the new installation was named the Naval Education and Training Center.

In 1980, the Department of the Navy developed the Naval Assessment and Control of Installation Pollutants (NACIP) program to identify and control environmental contaminants from past use and disposal of hazardous substances at naval installations. The program was to be managed in three phases: the initial assessment study (IAS), the confirmation study (CS), and the remedial action. An IAS was conducted at NETC in 1983; it identified 18 potentially contaminated areas; nine were recommended for further studies, three required no further action, and six were outside the scope of NACIP. The confirmation study phase of the NACIP was completed in May 1986; it was an evaluation of six of the nine areas identified in the IAS.

On November 21, 1989, NETC was placed on the National Priorities List (NPL), at which time the Navy was mandated by CERCLA to conduct all necessary response actions. A remedial investigation/feasibility study (RI/FS) is currently in progress. The RI is intended to characterize the nature and extent of contamination; the FS identifies and evaluates alternatives for controlling and cleaning up the contamination. The Navy completed Phase 1 of the RI in November 1991.

Five areas at NETC are being investigated under the RI/FS. The locations of those areas are shown in Figure 2. A description of the study areas' histories and information about potential hazardous materials associated with the sites follow.

Old Fire Fighting Training Area (Site 09)

The Old Fire Fighting Training Area occupies about 5 acres on the northern shoreline of Coasters Harbor Island (Figure 2). The site was used from World War II to 1972 as a fire fighting training area. A 1943 construction drawing indicates that a water/oil mixture may have been piped to two structures referred to as "carrier compartments," where the mixture was ignited. Underground piping also led from the buildings to an oil/water separator (1).

The area was not investigated in detail during the IAS and CS. The site was not studied in the CS because the IAS concluded that the site did not warrant further action. In 1987, geotechnical borings being completed before expansion of the on-site child care facility identified subsurface soil contaminated with an oily substance. The Navy then decided to investigate the site further.

McAllister Point Landfill (Site 01)

McAllister Point Landfill is in the central portion of the NETC installation, along the shoreline of Narragansett Bay; it encompasses about 11.5 acres (Figure 2). From 1955 through the mid-1970s, this area was used as a landfill. Wastes were received from the Newport naval complex, including the operational areas (machine shops, electroplating operations, etc.), installation housing areas, and ships whose home port was Newport (before 1973). Throughout the period that the landfill operated, the landfill was extended out into the bay using the wastes as fill material.

From 1955 through 1964, wastes were trucked to the site, spread out with a bulldozer, and then covered over. In 1965, an incinerator was built at the landfill. From 1965 through 1970-71, it is estimated that 98% of all the wastes were burned before being disposed of in the landfill. The incinerator was closed because of air pollution problems. No residences were down wind of the incinerator location during the period that the incinerator operated; residential areas were developed after 1972. During the remaining years that the landfill operated, all wastes were disposed of directly into the landfill. A soil cover 3 feet thick was placed over the McAllister Point Landfill when it closed.

The landfill is reported to have received at least 200 gallons of PCB-contaminated oil. Also in the landfill are spent acids, waste paints, solvents, and waste oils (diesel, fuel, and lubricating oils) (1).

Melville North Landfill (Site 02)

The landfill area was excessed by the Navy in September 1983 to the State of Rhode Island. Six months later, the state sold the site to Melville Marine Industries, which plans to develop a marina (1). The Melville North Landfill was sold prior to the placement of NETC on the NPL and is not considered within the boundaries of NETC. The Melville North Landfill is outside the scope of EPA's oversight and approval authority. Upon listing of the landfill on the NPL, the investigation into the landfill would then be subject to the review and approval of EPA. However, since information was provided and the landfill is potentially of public concern, ATSDR has included the Melville North Landfill in this public health assessment.

The Melville North Landfill is at the northern end of the NETC installation and is approximately 10 acres in size (Figure 2). The landfill is in a low-lying wetland-type area along the shoreline of Narragansett Bay; the area is subject to periodic flooding and lies within the 100-year floodplain (4).

The area was used as a landfill following World War II until 1955. The date that the landfill first began operations is not known, but all indications are that the landfill was operating after World War II (1). The size of the actual landfill has not been determined. The area used for landfilling activities could not be documented during previous site investigations. Aerial photographs provide some information on the suspected primary fill areas and the location of former man-made lagoons. The lagoons are believed to have been in the central portion of the site. There is no visible, mounded landfill area.

The landfill has some vegetation, primarily grass, weeds, and trees. A strip of trees is on the western part near the bay. A larger stand of trees is on the south side of the site. The north central part of the site has a small marshy area. Several areas have no vegetation.

The Melville North Landfill received wastes including spent acids, waste paints, solvents, waste oils (diesel, fuel, lube), and potentially PCBs. The quantity of those wastes disposed of in the landfill is unknown.

Tank Farm Four (Site 12)

Tank Farm Four, which covers about 80 acres, is on the northern part of the NETC installation, within 1300 feet of Narragansett Bay (Figure 2). The tank farm was used for storage of diesel and fuel oil; it consists of twelve 2,520,000 gallon underground storage tanks (USTs) and associated pump/valve houses. Other facilities include a small metal building that was used as an electrical substation, a wooden pole barn that was used for hay storage, and a concrete structure apparently used as on oil-water separator (1). The site was leased and used as grazing land for dairy cows from May 1979 to March 1992; the lease was terminated March, 1992.

Tank bottom sludge from Tank Farm Four was disposed of directly onto the ground in the vicinity of the tank being cleaned. Between 100,000 and 190,000 gallons of oil sludge were disposed of at Tank Farm Four. The sludge is no longer evident on the surface; at one time, it probably covered the entire tank farm (1). Sludge was disposed of on-site from World War II until the mid-1970s. When use of the tanks was discontinued, they were emptied (but not cleaned) and re-filled with water for ballast (1).

Tank Farm Five (Site 13)

Tank Farm Five, which covers approximately 80 acres, is at the north-central part of the NETC installation. The area is about 1000 feet east of Narragansett Bay; Defense Highway is between Tank Farm Five and the bay (Figure 2).

The tank farm was used for storage of diesel and fuel oil and consisted of eleven 2,520,000 gallon USTs. Two of the USTs were used for waste oil storage after other tanks on-site were taken out of service. NETC is permanently closing and remediating those two tanks. Other facilities at Tank Farm Five include the new Fire Fighting Training Facility, a small metal building that was used as an electrical substation, and a concrete structure apparently used as an oil-water separator.

Tank bottom sludges were reported to have been burned on site in a burning pit that had steel sides and a sand bottom. Between 100,000 and 175,000 gallons of tank bottom sludge, obtained during cleaning operations, was disposed of in the burning pit. Sludge was disposed of on-site from World War II until the mid-1970s.

B. Site Visit

Maurice C. West, Richard F. Collins, and Louise House (ATSDR Region I representative) visited NETC on April 29-30, 1991. Discussions were held with representatives from NETC Public Works Department, Environmental Section, the U.S. Environmental Protection Agency (EPA), Region 1, and the Rhode Island Department of Environmental Management about the status of the RI/FS. Health issues were discussed with personnel from NETC Health and Safety, Naval Hospital Industrial Hygiene, and Naval Hospital Preventive

Medicine. ATSDR also met with members of the community to discuss their concerns. Upon concluding discussions, the Installation Restoration Program (IRP) manager conducted a site tour for ATSDR staff. Following is a summary of observations made during the tour.

Old Fire Fighting Training Area

The site currently consists of a day care facility (which includes a fenced playground), a baseball field, a picnic area, and a playground. The predominant groundcover at the site is grass. Two grass covered mounds on the site suggest that the area has been backfilled over natural ground. One mound, in the center of the site, is about 15 feet high and is adjacent to the fenced day care playground. The second is about 6 feet high and is on the western corner of the site.

McAllister Point Landfill

The site visit group entered this area through a locked gate. No activity was observed. The site is vegetated with grass, weeds, and some small trees. Water had accumulated on the ground from previous rains. Two monitoring wells were seen on-site. The fill area drops sharply in elevation to Narragansett Bay; some solid debris was noticed along the steep face.

Melville North Landfill

The landfill is fenced and has a locked gate that prevents vehicles from entering; the gate would not prevent pedestrian access. The fence is posted with a "Private Property, No Trespassing" sign. Water had accumulated on the ground from previous rains. The site is generally covered with grass, weeds, and small trees; there are more mature, wooded areas on the southern part of the site. Several areas had no vegetation. Soil samples were being taken by the Navy's contractor (1).

Mounds of what appeared to be oil soaked soil have been deposited on the site. The Navy plans to remove these soil mounds from the area (1).

Tank Farm Four

Tank Farm Four is well vegetated with grass, weeds, brush, and some trees. There was no visible surface evidence of past tank bottom sludge disposal practices. The Navy had leased the site to a dairy farmer, and cattle were grazing on the land during the site visit. A stream, Normans Brook, crosses the western corner of the area and flows off site to

Narragansett Bay. Surface runoff is to the west. No surface debris was noted, with the exception of concrete structures associated with the USTs.

Tank Farm Five

The site visit group entered Tank Farm Five from the west, off of Defense Highway. Just inside the entrance and north of the access road is the new Fire Fighting Training Facility. The training area covers about 3 acres; it is surrounded by a chain link fence. A stream, Gomes Brook, runs through the northeastern part of the site. The stream flows off site into Narragansett Bay. Surface runoff is to the north. The site is vegetated with grass, weeds, dense brush, and some trees. Tanks 53 and 56 are scheduled for closure. During the site visit, one of the tanks was being closed; its contents were being pumped and treated.

C. Demographics, Land Use, and Natural Resource Use

Demographics

The population of Newport County is about 66,000; Newport accounts for 33,000, Middletown for 18,000, and Portsmouth for 15,000. The census tracts for the area had a total 1990 population of 64,544; 50.1% of residents were men; 49.9% were women. About 92% of the total population were white, 5.2% were black, and 2.8% were of other races. Just over 2% were of Hispanic origin (persons of Hispanic origin may be any race). Children under age 10 accounted for 3.2% of the population; 12.5% of the population were age 65 or older.

The 1990 census indicated that there were 24,096 households (i.e., occupied housing units), and an average of 2.5 persons per household. About 6% of the total population lived in group quarters, such as college dormitories or military installation barracks; those quarters are not counted as households. Close to 52% of all households were owner occupied. That relatively low percentage suggests a largely transient population (i.e., renters tend not to stay in a particular residence for an extended period of time). The median value of owner-occupied housing units was well over $100,000 in all census tracts, indicating the presence of affluent neighborhoods in the area (5).

Land Use

NETC and the Naval Construction Battalion Center Davisville (partially active) are the only two federal military installations in the Narragansett Bay area. Land use on Aquidneck Island has been classified by Rhode Island as either commercial, residential, industrial, or open space. Areas surrounding NETC are primarily residential and open space (4).

The economy of Newport depends on tourism and resort attractions; fishing and shellfish industries are also significant components. Middletown is home to several large defense-related corporations. Those industries and agriculture are the basis of Middletown's economy. The economic base of Portsmouth is industrial and agricultural (6).

Current land use at the Old Fire Fighting Training Area on Coasters Harbor Island includes The Teddy Colbert Child Care Center, a picnic area, a playground, a baseball field, and related military support services. The child care facility accepts a maximum of 52 children, ages 6 weeks to 5 years (7), and employs about 14 people (8). Tank Farm Four has been leased as grazing land for dairy cows, but the lease was terminated in March 1992. The Melville North Landfill has been purchased by Melville Marine Industries; the area is currently vacant, but the owners plan to develop a marina (1).

No major changes in land use are proposed by the municipalities of Newport, Middletown, and Portsmouth. There are plans to build a Boys Town mini-campus on the northern shore of Lawton Valley Reservoir, about one-half mile northeast of Tank Farm Four (9).

Natural Resources

Natural resources in the area include surface water, groundwater, and aquatic wildlife. The City of Newport provides public water to NETC and to the cities of Newport, Middletown, and Portsmouth. Lawton Valley Reservoir, St. Mary's Pond, and Sisson Pond in Portsmouth are the surface water sources used for the City of Newport water supply (10). The reservoirs are hydraulically upgradient of the NETC site study areas.

Some residential wells in Portsmouth and Newport are being used as sources of potable water. About 20 residential wells in Portsmouth are in use north of Melville Pond. A new subdivision is being developed in the area; therefore, additional residential wells will be established (9). Middletown has residential wells in the eastern section of town, in the area of Turner Road and Berkley Avenue, and east of Paradise Avenue (11). The wells are 1-2 miles upgradient from the NETC sites. No wells were identified that were being used for agricultural purposes in the Newport/Middletown/Portsmouth area.

The Narragansett Bay is of great economic importance. It is an estuary, and its fishing resources are important. The bay supports commercial, private, and tourist fishing. The bay's water quality is determined by the State of Rhode Island (Figure 3). Most of the waters along the NETC installation are classified as polluted areas; they are considered suitable for fish, shellfish, and wildlife habitat areas, but shellfish cannot be harvested. The area north of Coddington Cove to Carr Point is classified as suitable for direct shellfish harvesting, bathing, and other water contact activities (12, 13). That area includes the coastal region along Tank Farm Four (14).

D. State and Local Health Data

The State of Rhode Island provided ATSDR with vital statistics annual reports for 1980, 1985, and 1988. Those reports, which included information at the census tract level for the NETC area, are discussed further in the Health Outcome Data Evaluation section of this public health assessment.

COMMUNITY HEALTH CONCERNS

ATSDR evaluated community concerns by contacting concerned citizens groups, the state health department, and the public affairs officer (PAO) for the installation. The PAO sent out news releases inviting the public to meet with ATSDR and discuss concerns. Following are concerns raised by the ten attendees of the meeting:

- the possible association between cancer incidence and the landfills.
- the possible contamination of groundwater supplies used for drinking water.

Those community concerns will be addressed in the Community Health Concerns Evaluation section of this public health assessment.

ENVIRONMENTAL CONTAMINATION AND OTHER HAZARDS

A. Introduction

Chemicals selected as contaminants of concern are listed in the tables in the following section. Data for this section were taken from the RI technical report (1). ATSDR selects and discusses contaminants of concern using the following information:

1. concentrations of contaminants on and off site;
2. the quality of field data, laboratory data, and sample design;
3. comparison of on-site and off-site concentrations with comparison values for noncancer and cancer endpoints; and
4. community health concerns.

The data tables include the following acronyms/abbreviations:

- EMEG - Environmental Media Evaluation Guide
- RfDC - Reference Dose Concentration
- CREG - Cancer Risk Evaluation Guide
- LTHA - Life Time Health Advisory
- MCL - Maximum Contaminant Level
- ppb - parts per billion
- ppm - parts per million

ATSDR uses comparison values -- media-specific contaminant concentrations considered protective of public health -- to select contaminants for further evaluation. ATSDR and other agencies have developed the comparison values to provide guidelines for estimating contaminant concentrations in media that are not likely to cause adverse health effects, given a standard daily ingestion rate and standard body weight. The comparison values include environmental media evaluation guides (EMEGs), reference dose concentrations (RfDCs), and cancer risk evaluation guides (CREGs). An EMEG is the media-specific contaminant concentration that results in an exposure dose equivalent to ATSDR's minimal risk level (MRL). The MRL is an estimate of the daily human exposure to a contaminant that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure. The reference dose concentration (RfDC) is a medium-specific concentration that results in an exposure dose equivalent to EPA's reference dose (RfD). The RfD is an estimate of the daily exposure to a contaminant below which adverse noncancer health effects are not expected. CREGs are estimated contaminant concentrations expected to cause no more than one excess cancer in a million persons exposed over a lifetime (70 years). The EMEG, RfDC, and CREG are calculated using a standard intake rate and body weight for the specified population. EPA's lifetime health advisories (LTHAs) and maximum contaminant levels (MCLs) are contaminant concentrations at which no adverse public health effect are observed (considering the availability and economics of water treatment technology) over a lifetime (70 years) at an ingestion rate of 2 liters of water per day. LTHAs and MCLs are regulatory concentrations.

The following assumptions were used to calculate comparison values (EMEG, CREG, and RfDC) used in this public health assessment:

Child - Body weight = 10 kg
Water ingestion rate = 1 liter/day
Soil ingestion rate = 200 mg/day
Pica soil ingestion rate = 5000 mg/day

Adult - Body weight = 70 kg
Water ingestion rate = 2 liters/day
Soil ingestion rate = 100 mg/day

Contaminants listed in EPA's Integrated Risk Information System (IRIS) as human carcinogens (class A) or probable human carcinogens (class B) are listed as contaminants of concern.

In the contaminants tables, analytical results for chromium do not distinguish between trivalent (chromium III) and hexavalent chromium (chromium VI), but are listed as total chromium concentrations. To better protect public health, the comparison values used for chromium were calculated using the more toxic form, hexavalent chromium. That decision was made because electroplating operations had taken place in the past at NETC, and it is not known where the sludge was disposed (3). However, due to degradation, chromium is expected to be predominantly in the chromium (III) state in most soils.

Contaminants of concern are evaluated in the Toxicologic Evaluation section of this public health assessment; that evaluation helps determine if exposure to the contaminants has public health significance. In the data tables in the On-site and Off-site Contamination subsections, the listing of a contaminant does not mean that it will cause adverse health effects if people are exposed at the specified concentrations. Rather, the list identifies which contaminants will be evaluated further in this public health assessment for possible adverse health effects.

In order to identify possible facilities in the site area that might have contributed to contamination near NETC, ATSDR searched the Toxic Release Inventory (TRI). TRI is an on-line database, maintained by EPA, containing information (self-reports from chemical manufacturers and other companies throughout the United States) about more than 320 different substances released from facilities into the environment between 1987 and 1989. During 1987, 1988, and 1989, air releases of freon 113, 1,1,1- trichloroethane, dichloromethane, styrene, toluene, methanol, n-butyl alcohol, copper, nickel, cobalt and chromium were reported. ATSDR reviewed the available data and was unable to determine if these releases contributed to contamination at the site. Also reported were releases into water of 1,1,1-trichloroethane (l lb), dichloromethane (1 lb), freon 113 (1 lb), and methanol (250 lbs). One of these chemicals, 1,1,1-trichloroethane was detected at Tank Farm Five, however due to the location of the release it is unlikely to have contributed to the contamination detected on base.

B. On-site Contamination

Overview of Field Investigation

Table 1 is a summary of the key elements of the field investigation program, which was conducted between November 1989 and July 1990. Field investigation activities began at McAllister Point Landfill in November 1989 (1). Field investigation activities at the other four sites began in April 1990 and were completed, along with some additional work at McAllister Point, in July 1990.

Ambient air and radiologic surveys were conducted to locate any previously unidentified, potentially contaminated areas, and as a health and safety precaution. No organic vapors or radiation levels above background were detected during the general surveys at any of the sites. Electromagnetic and magnetic surveys were used as an aid in determining the locations of buried conductive or metallic objects and buried conductive waste areas. The findings of the geophysical surveys were used to determine the final locations of borings and wells.

Soil gas surveys were conducted to identify the presence of volatile organic compounds (VOCs) in subsurface soil vapors. The results of the soil gas surveys were evaluated to determine if planned locations for borings or monitoring wells should be changed to better investigate areas of suspected subsurface contamination. The results of the soil gas surveys were reported as total VOC values. Because the data are not broken down by compound, they cannot be used to determine potential adverse health effects. Consequently, the data are not reported in the sections on contaminants of concern.

TABLE 1
Field Investigation Program Summary

Ambient Air and Radiologic Surveys - Conducted at all sites using organic vapor analyzers, photo-ionization detectors, and radiation meters.

Geophysical Surveys - Electromagnetic surveys and magnetometer surveys were conducted at sites 01, 02, and 13.

Soil Gas Surveys - Conducted at sites 09, 12, and 13.

Surface Soil Sampling - Conducted at each site.

Test Pit Operations - Conducted at site 02.

Subsurface Soil Borings - Conducted at sites 01, 02, 09, 12, and 13.

Groundwater Monitoring Well Installation - Conducted at each site.

Groundwater Sampling - Conducted at each site.

Surface Water/Sediment Sampling - Conducted at sites 02, 12, and 13.

Sediment and Mussel Sampling - Originally proposed for Sites 01, 02, and 09 but abandoned because of the lack of approved analytical methods for samples. Sampling was scheduled to occur during Phase II of the Remedial Investigation.

Underground Storage Tank Investigations - Conducted at sites 12 and 13.

Structure Investigations - Conducted at sites 12 and 13.

Ref (1)

All sample analyses were performed according to EPA Contract Laboratory Program (CLP) protocols. Non-CLP analyses were performed using established, current EPA protocols. Generally, soil and water samples were analyzed for EPA's full list of target compound list (TCL) organic compounds and target analyte list (TAL) metals. A list of the TCL and TAL parameters is provided in Appendix A. Surface soil and soil boring samples from all sites were archived for dioxin/furan analysis. The analyses were completed in 1993.

Surface soil samples collected from a depth of at least 6 inches below the surface were analyzed for total petroleum hydrocarbons and VOCs. All other surface soil samples were collected from the 0- to 6-inch interval. ATSDR defines surface soil as 0-3 inches below the surface; however, because of the lack of appropriate samples, the previously described samples were defined as surface soil samples and evaluated in the Contaminants of Concern and Toxicologic Evaluation sections of this public health assessment. The specifics of sample analyses are addressed in the individual site study area discussions.

The study areas at NETC are geographically distinct. In the following discussion of environmental contamination, each study area is considered separately. Summary maps for each site are provided in Figures 4-8. A short discussion of the site's hydrogeology, geography, and hydrology is given to aid in understanding the potential for contaminant migration from each study area.

Old Fire Fighting Training Area

This 5-acre study area is at the northern end of Coasters Harbor Island. Currently on site are a child care facility, picnic area, playground, and baseball field. The site is characterized by two mounds: a 15-foot mound in the center of the site and a 6-foot mound at the western end of the site.

The overburden material consists of fill over till deposits. The thickness of the fill material ranges from 0 to 4 feet across the site. The fill materials consist primarily of fine sand and silt and construction-type debris. The native overburden deposits identified at the site include a continuous, very tight sand-and-gravel till, a discontinuous silt-and-fine sand till, and organic swampy muck. Bedrock, composed of sandstone, was encountered at depths of 5.5 to 10.2 feet below grade during this and previous investigations.

Groundwater flow is generally from south to north towards Narragansett Bay (Figure 9). Vertical hydraulic gradient could not be measured because there are no nested monitoring wells (wells in the same location with screens at different depths) on site. Calculated average horizontal velocities for shallow groundwater range from 2.92 to 5.11 feet/year (ft/yr). Tidal influences on groundwater were detected during continuous water level measurements (over a 3-day period) at three of the five monitoring wells. The fluctuations ranged from 0 to 0.91 feet.

Subsurface Soil

The subsurface investigation included drilling seven test borings and five monitoring well borings across the site (Figure 4). Continuous split spoon sampling was conducted in all of the soil borings. The test borings were completed to a depth just beyond any observed contamination. One to three soil samples were collected from each soil boring for analysis. If three samples were submitted for analysis, they included a sample from the highest observed contamination; a sample from the approximate location of the water table; and a sample from the bottom of the boring. Generally, soil borings were analyzed for all of the TCL and TAL parameters.

All carcinogenic polynuclear aromatic hydrocarbons (PAHs) detected were chosen as contaminants of concern. Subsurface soil contaminants considered to be of concern and their associated comparison values (when available) are shown in Table 2.

Surface Soil

Surface soil samples were collected from six locations across the Old Fire Fighting Training Area (Figure 4). The samples were collected from areas of concern because of the potential for human exposure (e.g., child care center, baseball field, park) and from other areas that could provide an indication of areal surface soil contamination (such as the soil mounds and the shoreline). One discrete surface soil sample was taken from each of the following areas: child care center playground, baseball field, large soil mound in the center of the site, soil mound at the western end of the site, at the shoreline, and at the pavilion/park area. All of the surface soil samples were analyzed for the full list of TCL and TAL parameters. analyses.

One surface soil sample (SS-02) taken from the day care playground area was collected as a split sample. One analysis of the sample found elevated levels of several contaminants, primarily metals (15). However, the other analysis of the spilt sample did not indicate elevated levels. Given the current use of the area by a day care facility, it was decided that the location would be resampled (December 1991) to resolve inconsistencies and identify potential human health concerns. Six additional samples were analyzed for metals. Analysis of those samples determined that contaminants (metals) were not elevated in the fenced playground area. Therefore, the results for sample SS-02 were determined as invalid and were not used for selection of metals as contaminants of concern at the Old Fire Fighting Training Area.

All carcinogenic PAHs detected were selected as contaminants of concern. Surface soil contaminants of concern and their associated comparison values (if available) are shown in Table 3.

Table 2. Maximum Contaminant Concentrations in On-site Subsurface Soil Samples Fire Fighting Training Area

Contaminant	Maximum Conc. (ppm)	Depth (feet)	Comparison Value (ppm)	Reference
PAHs *Benz(a)Anthracene	0.8	8-10	N/A	N/A
*Chrysene	0.95	8-10	N/A	N/A
*Benzo(b)Fluoranthene	0.68	8-10	N/A	N/A
*Benzo(k)Fluoranthene	0.53	8-10	NA/	N/A
*Benzo(a)Pyrene	0.7	6-8	0.12	CREG
*Indeno(1,2,3-cd) Pyrene	0.62	6-8	N/A	N/A
*Dibenzo(a,h) Anthracene	0.140**	6-8	N/A	N/A
2-Butanone	1.100**	6-8	N/A	N/A
2-Methylnaphthalene	0.670**	4-6	N/A	N/A
Phenanthrene	1.4	12-14	N/A	N/A
*Arsenic	8.6	6-8	0.6	RfDC pica child
Cadmium	8.1	6-8	0.4	EMEG pica child
Chromium	20.6**	12-14	10	RfDC pica child
Manganese	1020**	12-14	200	RfDC pica child
Antimony	12.2	12-14	0.8	RfDC pica child
*Lead	529	6-8	N/A	N/A

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database
** Indicates numerical value is an estimated quantity

Ref (1)

Table 3. Maximum Contaminant Concentrations in On-site Surface Soil Samples Old Fire Fighting Training Area

Contaminant	Maximum Conc. (ppm)	Depth (inches)	Comparison Value (ppm)	Reference
PAHs *Benz(a)Anthracene	3.3	6-12	N/A	N/A
*Chrysene	2.8	6-12	N/A	N/A
*Benzo(b)Fluoranthene	2.8	6-12	N/A	N/A
*Benzo(k)Fluoranthene	3.1	6-12	N/A	N/A
*Benzo(a)Pyrene	2.7	6-12	0.12	CREG
Naphthalene	0.48**	6-12	N/A	N/A
Phenanthrene	7.2	6-12	N/A	N/A
*PCB-1254	0.08	0-6	0.01	EMEG pica child
Cadmium	0.94	0-6	0.4	EMEG pica child
Copper	44.3	0-6	N/A	N/A
*Arsenic	8.9	0-6	0.6	RfDC pica child
*Lead	77.8	0-6	N/A	N/A
Vanadium	36.3	0-6	N/A	N/A
Antimony	5.6	0-6	0.8	RfDC pica child
Manganese	750	0-6	200	RfDC pica child
Chromium	18.8	0-6	10.0	RfDC pica child

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database
** Indicates numerical value is an estimated quantity

Ref (1)

Groundwater

Five monitoring wells (Figure 4) were installed to investigate the nature and extent of groundwater contamination at the Old Fire Fighting Training Area. Four of the wells were installed on the site; one well was installed upgradient and off site. All wells were installed in the overburden and fill material at the site. The off-site well was installed to provide background information on groundwater quality upgradient of the site. The monitoring wells were installed between April 23 and April 26, 1990. The wells were sampled on July 19, 1990. The monitoring well samples were analyzed for all TCL and TAL parameters.

All carcinogenic PAHs detected were selected as contaminants of concern. Inorganic compounds exceeding comparison values include arsenic, cadmium, manganese, and lead. Groundwater contaminants of concern and associated comparison values are listed in Table 4.

Table 4. Contaminant Concentration in On-site Groundwater (Old Fire Fighting Training Area)

Contaminant	Maximum Conc. (ppb)	Comparison Value (ppb)	Reference
PAHs *Benz(a)Anthracene	3**	N/A	N/A
*Chrysene	4**	N/A	N/A
*Benzo(a)Pyrene	2**	0.006	CREG
*Bis(2-Ethylhexyl) Phthalate	740	205	CREG
2-Methylnaphthalene	300	N/A	N/A
*Benzene	2	1.2	CREG
*Arsenic	16.6*	3	RfDC child
Cadmium	48.8	2	EMEG child
Manganese	8270	1000	RfDC child
*Lead	4120*	50	MCL

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database
** Indicates numerical value is an estimated quantity

Ref (1)

McAllister Point Landfill

McAllister Point Landfill received nearly all the wastes generated at NETC for a period of almost 20 years. The landfill is believed to contain spent acids, waste paints, solvents, and waste oils. The landfill is reported to have received 200 gallons of PCB-contaminated oil.

The material overlaying the bedrock at the landfill consists of fill and glacial till deposits. The fill material ranges from 3 to 24 feet in thickness. Many areas of the fill are overlaid by a clay-silt cap layer; however, the layer is not continuous. The bedrock consists of a gray-green to black, highly weathered to competent, carboniferous shale. Cores of the shale showed signs of a high degree of fracturing. Depth to bedrock ranges from 4 to 24 feet (1).

Groundwater flow is east to west towards Narragansett Bay (Figure 10). The rate at which water flows through the weathered bedrock materials is higher than values normally attributed to shale, and probably reflects the highly weathered and fractured nature of the upper portion of the bedrock at the site. Negative vertical hydraulic gradients were measured in the two sets of nested monitoring wells on site (1).

Vertical hydraulic gradients are evaluated to determine whether contamination can migrate downward through an aquifer. A positive hydraulic gradient indicates an upward flow, and a negative gradient indicates a downward flow. An upward flow would tend to retard contaminant transport down through an aquifer; a downward flow, on the other hand, is a means by which contamination can migrate toward the bottom of the aquifer (1).

The negative vertical hydraulic gradient measured at the nested monitoring wells indicates that groundwater from above the bedrock surface (in the fill or overburden) would tend to flow downward into the bedrock. The average horizontal velocities estimated for the shallow groundwater range from 2.23 to 15.22 ft/yr. Velocities for the deep groundwater are estimated to range from 2.08 to 3.32 ft/yr. Tidal influences on groundwater were evaluated during varying tidal levels (over a 3-day period) at most on-site wells. The greatest fluctuation (more than 2 feet) was measured in a bedrock well (1).

Site topography generally slopes in an east to west direction. During periods of heavy rain, water collects in a small depression on the north-central part of the site. The western edge of the site (bordering the bay) is characterized by a steep slope to the shoreline. Springs have been observed discharging from the bottom of the landfill bank into the bay (1).

<u>Subsurface Soil</u>

The subsurface investigation at McAllister Point Landfill included the drilling and sampling of 11 test bore holes and nine well borings (Figure 5). One boring was made east of the site (across Defense Highway on property belonging to a cemetery) to provide information on background subsurface soil quality. A total of 33 boring samples were taken at depths ranging from 2 to 24 feet. Soil boring samples were generally analyzed for all of the TCL and TAL parameters. One of the samples (B1-4) containing some gray ash layers was submitted for toxicity characteristics leaching procedure (TLCP) analysis (1).

Contaminants of concern include carcinogenic polynuclear hydrocarbons, semivolatile organic compounds, PCB-1242, and lead. All subsurface soil contaminants of concern and their associated comparison values, if available, are shown in Table 5.

Table 5. Maximum Contaminant Concentrations in On-site Subsurface Soil Samples McAllister Point Landfill

Contaminant	Maximum Conc. (ppm)	Depth (feet)	Comparison Value (ppm)	Reference
PAHs *Benz(a)Anthracene	120	18-20	N/A	N/A
*Chrysene	12	18-20	N/A	N/A
*Benzo(b)Fluoranthene	78	18-20	N/A	N/A
*Benzo(k)Fluoranthene	78	18-20	N/A	N/A
*Benzo(a)Pyrene	86	18-20	0.12	CREG
*Indeno(1,2,3-cd) Pyrene	36**	18-20	N/A	N/A
*Dibenzo(a,h) anthracene	84**	18-20	N/A	N/A
*PCB-1242	0.24	18-20	0.091	CREG
*Lead	2050	10-12	N/A	N/A
Naphthalene	82	18-20	N/A	N/A
Phenanthrene	370	18-20	N/A	N/A

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database
** Indicates numerical value is an estimated quantity

Ref (1)

Surface Soil

Seventeen surface soil samples -- 15 on site and 2 off site -- were taken at McAllister Point Landfill (Figure 5). All on-site samples were taken outside the reported-to-have-been-capped area of the landfill. Four samples were taken along the shoreline of Narragansett Bay, and 11 samples were collected outside of established fill areas.

All on-site surface soil samples were analyzed for the full list of TCL organics, TAL metals, and cyanide. The two off-site surface soil samples were analyzed for TAL metals to provide an indication of background metal concentrations in area soils (1).

All carcinogenic PAHs detected were selected as contaminants of concern. Surface soil contaminants of concern and their comparison values (if available) are listed in Table 6.

Groundwater

Samples were collected from 12 monitoring wells at the McAllister Point Landfill (Figure 5). Eleven of the wells are on site; one is about 300 feet northeast and upgradient of the site. The wells are screened in various geologic formations, including unconsolidated overburden and fill, competent bedrock, and weathered bedrock. Samples were also collected from the leachate spring flowing from the western edge of the landfill. All groundwater samples were analyzed for all TCL and TAL parameters.

Benzene was the only VOC found in the groundwater monitoring wells at levels exceeding its comparison value. Several inorganic compounds exceeding comparison values were found in samples from the groundwater monitoring wells, including arsenic, barium, beryllium, cadmium, mercury, manganese, nickel, lead, antimony, and vanadium. Two inorganic compounds, antimony and vanadium, were found at levels exceeding their comparison values in the samples taken from the leachate spring. The concentrations of groundwater contaminants of concern and their respective comparison values are listed in Table 7.

Table 6. Maximum Contaminant Concentrations in On-site Surface Soil Samples McAllister Point Landfill

Contaminant	Maximum Conc. (ppm)	Depth (inches)	Comparison Value (ppm)	Reference
PAHs *Benz(a)Anthracene	180	6-12	N/A	N/A
*Chrysene	16	6-12	N/A	N/A
*Benzo(b)Fluoranthene	15	6-12	N/A	N/A
*Benzo(k)Fluoranthene	14	6-12	N/A	N/A
*Benzo(a)Pyrene	16	6-12	0.12	CREG
*Indeno(1,2,3-cd) Pyrene	8.9	6-12	N/A	N/A
*Dibenzo(a,h) Anthracene	6.4	6-12	N/A	N/A
PCB-1242	0.61**	0-6	0.091	CREG
Naphthalene	3	0-12	N/A	N/A
Cadmium	21.8	0-6	10	EMEG child
Copper	6070	0-6	N/A	N/A
*Arsenic	15.8	0-6	15	RfDC child
*Lead	362	0-6	N/A	N/A
Manganese	574	0-6	5000	RfDC child
Vanadium	36.7	0-6	N/A	N/A
Zinc	2040	0-6	N/A	N/A
Mercury	1.6	0-6	N/A	N/A

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database
** Indicates numerical value is an estimated quantity

Ref (1)

Table 7. Maximum Contaminant Concentration in On-site Groundwater McAllister Point Landfill

Contaminant	Maximum Conc. (ppb)	Comparison Value (ppb)	Reference
*Benzene	6	1.2	CREG
*Arsenic	85.8**	3	RfDC child
Barium	1770**	700	RfDC child
*Beryllium	12.8	0.0081	CREG
Cadmium	57.1**	2	EMEG child
Mercury	8.4	2	MCL
Nickel	678	100	LTHA
*Lead	4800**	50	MCL
Antimony	259**	4	RfDC child
Vanadium	109**	20	LTHA
Contaminant (leachate spring)	**Maximum Conc. (ppb)**	**Comparison Value (ppb)**	**Reference**
Antimony	77.1	4	RfDC child
Vanadium	79.2	20	LTHA

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database
** Indicates numerical value is an estimated quantity

Ref (1)

Melville North Landfill

Spent acids, paints, waste oils, and, possibly, PCBs were disposed of at Melville North Landfill. Oil-stained soil appears to have been deposited on the northern part of the landfill. Areas with stressed vegetation and oil stains are apparent in the former lagoon area.

Overburden material consists of fill and glacial till deposits. Fill thickness ranges from 2 feet to 10 feet. Fill material includes primarily loose, black, medium-to-coarse sand and gravel and bits of shale. Glacial till deposits were seen under the fill that covers the site. The till consists of silt, with up to about 50% fine-to-coarse sand in some areas.

Groundwater contours indicate that the site groundwater is flowing from east to west towards the bay (Figure 11). The rate at which water flows through the fill material indicates that the fill is approximately twice as conductive as the till.

No vertical hydraulic gradients were determined. Average horizontal velocities of the shallow groundwater ranged from 1.93 ft/yr to 24.29 ft/yr.

Subsurface Soil

Thirteen test borings and five monitoring well borings (Figure 6) were conducted across the site. Continuous split spoon sampling was conducted at all the test borings, and well borings were screened with an OVA (organic vapor analyzer) and/or HNu (photo- ionization detector) for signs of contamination. Test borings were completed to a depth of just beyond any observed contamination or fill material. Test well borings that did not encounter fill were completed to a depth of 6 ft. Well borings were drilled to an adequate depth for installation of a water table monitoring well. Seven shallow test pit excavations were completed around or near the former lagoon area (central part of the site). Soil samples were collected from four of the test pits. All soil samples were analyzed for all TCL and TAL parameters. One soil boring sample was submitted for TCLP analysis.

VOCs were found in subsurface soils on the central part of the site in the suspected former lagoon area. High levels of VOCs were found on the southern part of the site at well boring 4. Inorganic compounds, at levels above comparison values, were found in subsurface soils. Semivolatile organic compounds were detected throughout the site. The highest levels were found in the northwestern corner, the central part, and the southern part. All carcinogenic PAHs detected were selected as contaminants of concern. PCBs and dioxins were detected at levels above comparison values. All compounds selected as contaminants of concern for subsurface soil and their corresponding comparison values (if available) are listed in Table 8.

Table 8. Maximum Contaminant Concentrations in On-Site Subsurface Soil Samples Melville North Landfill

Contaminant	Maximum Conc. (ppm)	Depth (feet)	Comparison Value (ppm)	Reference
PAHs *Benzo(a)Anthracene	6.1	0-2	N/A	N/A
*Chrysene	6.4	2-4	N/A	N/A
*Benzo(b)Fluoranthene	4.2	0-2	N/A	N/A
*Benzo(k)Fluoranthene	4.9	0-2	N/A	N/A
*Benzo(a)Pyrene	5.6	2-4	0.12	CREG
*Indeno(1,2,3-cd) Pyrene	3.3	0-2	N/A	N/A
Naphthalene	17	8-10	N/A	N/A
Phenanthrene	2.8	8-10	N/A	N/A
2-Methylphthalate	6.5	8-10	N/A	N/A
Benzo(g,h,i)Perylene	3.7	4-6	N/A	N/A
*PCB-1240	2.7	8-10	0.091	CREG
*PCB-1254	1.9	6-8	0.091	CREG
*Lead	5.92	4-6	N/A	N/A
Mercury	1.1	6-8	N/A	N/A
Vanadium	233	2-4	N/A	N/A
Cobalt	24.4	4-6	N/A	N/A
Copper	3284.6	4-6	N/A	N/A
Nickel	427	2-4	N/A	N/A
Total 2,3,7,8 TCDD Equivalent**	.0023047	3-4	.001	EMEG

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database
**The 2,3,7,8-TCDD Equivalency Factors were taken from the March 1989 update of "Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-dioxins and dibenzofuran (CDDs and CDFs) and 1989 Update" Where isomers specific results are not available, the most conservative equivalency factor (the highest) is applied to that isomer grouping.

Ref (1,16)

Surface Soil

Seventeen surface soil samples were taken at Melville North Landfill (Figure 6). Fifteen samples were analyzed for TAL and TCL parameters; two samples were analyzed for TCL and PCB compounds. Inorganic contaminants were found throughout the site. All carcinogenic PAHs detected are listed as contaminants of concern. The compounds selected as contaminants of concern for surface soil and their associated comparison values (if available) are listed in Table 9.

Groundwater

Five monitoring wells were installed at Melville North Landfill (Figure 6) to determine the nature and extent of contamination of the groundwater; four wells were placed on site; one well was placed upgradient and off site. Wells were established in April of 1990; sampling took place on July 18, 1990. Monitoring wells were installed in the overburden and fill materials. When possible, wells were placed near areas of suspected contamination. All well samples were analyzed for all TCL and TAL parameters (1). Only one VOC -- benzene -- exceeded its comparison value. Semivolatile organic compounds selected as contaminants of concern include naphthalene, 1,4-dichlorobenzene, 2-methylnapthalene, and phenanthrene. Numerous inorganic analytes were selected as contaminants of concern. The groundwater contaminants of concern and their associated comparison values (if available) are listed in Table 10.

Table 9. Maximum Contaminant Concentrations in On-Site Surface Soil Samples Melville North Landfill				
Contaminant	**Maximum Conc. (ppm)**	**Depth (inches)**	**Comparison Value (ppm)**	**Reference**
PAHs *Benzo(a)Anthracene	9.8	6-12	N/A	N/A
*Chrysene	11	6-12	N/A	N/A
*Benzo(b)Fluoranthene	6.4	6-12	N/A	N/A
*Benzo(k)Fluoranthene	6.8	6-12	N/A	N/A
*Benzo(a)Pyrene	7.5	6-12	0.12	CREG
*Indeno(1,2,3-cd) Pyrene	3.3	6-12	N/A	N/A
Benzo(ghi)Perylene	3.4	6-12	N/A	N/A
Silver	21.8	0-6	10	RfDC pica child
Barium	269	0-6	140	RfDC pica child
Antimony	10.3	0-6	0.8	RfDC pica child
*Arsenic	28.3	0-6	0.6	RfDC pica child
Chromium	35.2	0-6	10	RfDC pica child
Copper	13.5	0-6	N/A	N/A
Nickel	26.2	0-6	N/A	N/A
Vanadium	53.8	0-6	N/A	N/A
Zinc	547	0-6	N/A	N/A
*PCB-1260	8	0-6	.091	CREG

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database

Ref (1)

Table 10. Maximum Contaminant Concentration in On-Site Groundwater Samples (Melville North Landfill)

Contaminant	Maximum Conc. (ppb)	Comparison Value (ppb)	Reference
*Benzene	16	1.2	CREG
Naphthalene	100	20	RfDC child
1,4-Dichlorobenzene	83	75	LTHA
2-Methylnaphthalene	210	N/A	N/A
Phenanthrene	62	N/A	N/A
Cobalt	55	N/A	N/A
Barium	759	700	RfDC child
Copper	958	N/A	N/A
Chromium	62.8	50	RfDC child
Zinc	4170	2000	LTHA
Antimony	77.1	4	RfDC child
Manganese	2080	1000	RfDC child
Vanadium	203	20	LTHA

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database

Ref (1)

Sediment

Three sediment samples were collected from the wetlands area north of the site (Figure 6). Samples were analyzed for TAL and TCL parameters. At each location, a sample was taken at 0- to 1-foot intervals. Compounds selected as contaminants of concern for sediment and their associated comparison values (if available) are listed in Table 11.

Table 11. Maximum Contaminant Concentrations in On-Site Sediment Samples (Melville North Landfill)

Contaminant	Maximum Conc. (ppm)	Comparison Value (ppm)	Reference
PAHs *Benz(a)Anthracene	0.45	N/A	N/A
*Chrysene	0.62	N/A	N/A
*Benzo(b)Fluoranthene	0.45	N/A	N/A
*Benzo(k)Fluoranthene	0.43	N/A	N/A
*Benzo(a)Pyrene	0.43	0.12	CREG
*Indeno(1,2,3)Pyrene	0.26	N/A	N/A
*Arsenic	1.4	0.6	RfDC pica child
Manganese	460	200	RfDC pica child
Copper	99.7	N/A	N/A
Mercury	0.44	N/A	N/A
Nickel	83	N/A	N/A
*Lead	206	N/A	N/A
Zinc	585	N/A	N/A
Vanadium	24.7	N/A	N/A

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database

Ref (1)

Tank Farm Four

Diesel and fuel oil were stored in the past in the USTs at Tank Farm Four. Tank bottom sludges, totaling 100,000 to 190,000 gallons, were reported to have been disposed onto the ground on site.

The overburden materials consist of a native sand and silt and glacial till. The till was encountered in all borings, ranging in thickness from 12 to 29 feet across the site. No fill materials were encountered at the site. Bedrock was encountered at all boring locations and consisted of weathered shale over competent bedrock. Rock cores indicate the bedrock is of the same unit encountered at the McAllister Point Landfill site (1).

Groundwater flow direction for both shallow and deep groundwater at Tank Farm Four is generally to the southwest, towards Narragansett Bay. Both the shallow and the deep groundwater flow directions seem to be affected by the presence of Normans Brook, a gaining stream (receives discharge from the groundwater) on the southwestern part of the site (Figure 12). Estimated average horizontal velocities for shallow groundwater range from 22.99 to 105 ft/yr; for deep groundwater, they range from 83.95 to 255.5 ft/yr (1).

Normans Brook flows year-round across the southwestern corner of the site. Site topography generally slopes in an east to west direction. The central part of the site, where the tanks are located, slopes gradually and is well drained. During periods of heavy rainfall, water collects in a ditch that runs between the site and Defense Highway and in low-lying areas in the northern corner of the site. Piezometer and surface water level measurements indicate that Normans Brook receives discharge from the groundwater (1).

Subsurface Soil

Five monitoring well borings (Figure 7) were sampled when monitoring wells were installed at the site. Continuous split spoon sampling was conducted in all of the well borings, to a maximum of 20 feet or to 10 feet beyond the depth of the water table. All of the split spoon samples were screened with an OVA and/or HNu for signs of contamination. Because no signs of contamination were evident in any of the well borings, one soil sample was collected from each monitoring well boring at or near the water table. The soil samples were analyzed for all of the TCL and TAL parameters. One of the samples was also analyzed for total petroleum hydrocarbons (TPHs). No contaminants in the subsurface soil at Tank Farm Four were selected as contaminants of concern.

Surface Soil

Twenty-eight surface soil samples were collected at Tank Farm Four (Figure 7). Two samples were collected from around each of the 12 tanks and four from around the oil/water separator. The two surface soil samples from around each tank consisted of one composite sample from the tank area and one discrete sample from any area with signs of contamination (e.g., stains, stressed vegetation). If an area of potential contamination was not visible, the discrete sample was collected from the central part of the tank area. The surface soil samples were analyzed for the indicator analysis of TPH and lead. In addition, two of the composite surface soil samples were analyzed for the TCL and TAL parameters, plus TPHs (1). Those two samples were split with EPA for analyses. All carcinogenic PAHs detected were selected as contaminants of concern. Chemicals in surface soil selected as contaminants of concern and their associated comparison values (if available) are listed in Table 12.

Table 12. Maximum Contaminant Concentrations in On-site Surface Soil Samples Tank Farm Four

Contaminant	Maximum Conc. (ppm)	Depth (inches)	Comparison Value (ppm)	Reference
PAHs *Benzo(a)Anthracene	0.12	0-12	N/A	N/A
*Chrysene	0.14	0-12	N/A	N/A
*Benzo(b)Fluoranthene	0.086	0-12	N/A	N/A
*Benzo(k)Fluoranthene	0.49	0-12	N/A	N/A
*Benzo(a)Pyrene	0.530	0-12	0.12	CREG
Naphthalene	3	0-12	N/A	N/A
*Arsenic	15.8	0-6	15	RfDC child
*Lead	67.9	0-6	N/A	N/A
Manganese	73.9	0-6	5000	RfDC child
Chromium	16.6	0-6	250	RfDC child

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database

Ref (1)

Groundwater

Eight monitoring wells were installed at five locations on Tank Farm Four (Figure 7) to investigate the groundwater contamination. Five of the eight wells were screened in the overburden material, and three wells were screened in bedrock. Each bedrock well was nested with an overburden well. One well pair was installed immediately downgradient of the USTs. Another well pair was installed in the central part of the site, in the middle of the tank area. A third well pair was installed in a location upgradient of the USTs to assess shallow and deep background groundwater quality. The installation of the monitoring wells took place during May and June 1990. The monitoring wells were sampled on July 18, 1990. Groundwater samples were analyzed for TCL and TAL parameters (1). Contaminants exceeding comparison values were all inorganic compounds, including arsenic, cadmium, beryllium, lead, chromium, manganese, nickel, and vanadium. Maximum concentrations of all contaminants of concern and their respective comparison values are listed in Table 13.

Table 13. Contaminant Concentration in On-site Groundwater Tank Farm Four

Contaminant	Maximum Conc. (ppb)	Comparison Value (ppb)	Reference
*Arsenic	448	3	RfDC child
Cadmium	8.5	2	EMEG child
*Beryllium	8.5	0.0081	CREG
*Lead	136	50	MCL
Chromium	391	50	RfDC child
Manganese	11500	1000	RfDC child
Nickel	749	100	LTHA
Vanadium	168	20	LTHA

* Contaminants are Class A or B2 carcinogens per EPA IRIS database

Ref (1)

Surface Water and Sediment

Sediment and surface water samples were collected from Normans Brook (Figure 7), which runs through the southwestern part of the site and into Narragansett Bay. Six sediment samples were taken in Norman's Brook: four on site, one off site and upstream just beyond the site fence, and one off site and downstream at the mouth of the brook. Two sediment samples were collected from each location: one from 0-1 foot and the other from 1-2 feet below the sediment surface. Surface water samples were collected from four of the six sediment sample locations: two on site and one from each of the off-site locations. The surface water and sediment samples were analyzed for TCL and TAL parameters (1). No contaminants of concern were selected from the surface water samples. Contaminants of concern in sediment samples included arsenic, chromium, and lead. Those contaminants and their associated comparison values (if available) are listed in Table 14.

Table 14. Maximum Contaminant Concentrations in On-site Sediment Samples Tank Farm Four

Contaminant	Maximum Conc. (ppm)	Depth (feet)	Comparison Value (ppm)	Reference
*Arsenic	19.5	1-2	15	RfDC child
*Lead	16.4	0-1	N/A	N/A
Chromium	25.9	1-2	250	RfDC child

Ref (1)

Underground Storage Tanks

Oil samples were collected from each of the 12 USTs, and water samples were collected from 11 USTs to evaluate closure alternatives for the USTs. The data were not considered for selection of contaminants of concern. The only persons likely to be exposed to the compounds in the USTs would be remediation workers. If proper safety precautions are taken during remediation, exposure to those compounds will not be of public health concern.

Tank Farm Five

Diesel and fuel oil were stored in the past at Tank Farm Five. Tank bottom sludges were reported to have been burned on site in a burning pit. In addition, 100,000 to 175,000 gallons of oil sludge was reported to have been disposed of at the site.
The overburden material consists of a native silt and glacial till. The till was encountered in all borings, ranging in thickness from 1 to 21 feet across the site. The till directly overlies bedrock at Tank Farm Five. Bedrock was found at all boring locations; it consisted of gray, highly weathered to competent, slightly metamorphosed shale with quartz lenses. Rock cores indicate the bedrock is of the same unit encountered at the McAllister Point Landfill site. A considerable zone (up to 22 feet) of weathered bedrock overlies the competent bedrock (1).

Groundwater flow for the shallow groundwater is generally to the west-northwest, towards Narragansett Bay in the southern part of the site and to the north, towards Gomes Brook, in the northern part of the site (Figure 13). Estimated average horizontal velocities for shallow groundwater range from 7.92 to 18.25 ft/yr (1).

Gomes Brook flows year-round across the northeastern part of the site. Site topography generally slopes south to north. The central part of the site, in which the tanks are located, is gradually sloping and well drained. During periods of heavy rainfall, runoff from the site accumulates at the point where Defense Highway crosses Gomes Brook. Water also accumulates in a marshy area in the eastern corner of the site. Gomes Brook receives discharge from the groundwater.

Subsurface Soil

Six monitoring well borings were sampled (Figure 8) when monitoring wells were installed at Tank Farm Five. Continuous split spoon sampling was conducted in the well borings to a maximum of 20 feet, or to 10 feet beyond the depth of the water table. The split spoon samples were screened with an OVA and or HNu for signs of contamination. Because no signs of contamination were observed in the well borings, only one soil sample was collected from each monitoring well boring at or near the depth of the water table. The soil samples were analyzed for all of the TCL and TAL parameters. One of the samples was also analyzed for TPH. No chemicals were selected as contaminants of concern from the subsurface soil samples at Tank Farm Five.

Surface Soil

Twenty-six surface soil samples were collected on Tank Farm Five (Figure 8). The surface soil samples were collected as follows: two samples from each of the 11 tank areas and four around the burning pit structure. The two surface soil samples from around each tank consisted of one composite sample from the tank area and one discrete sample from any area with signs of contamination, such as stains or stressed vegetation. If an area of potential contamination was not visible, the discrete sample was collected from the central part of the tank area. The surface soil samples were analyzed for the indicator parameter of TPHs and lead. In addition, two of the composite tank surface soil samples were analyzed for TCL and TAL parameters plus TPHs (1). The two samples were split with EPA for analyses. All carcinogenic PAHs detected were selected as contaminants of concern. Surface soil contaminants selected as contaminants of concern and their associated comparison values are shown in Table 15.

Table 15. Maximum Contaminant Concentrations in On-site Surface Soil Samples Tank Farm Five

Contaminant	Maximum Conc. (ppm)	Depth (inches)	Comparison Value (ppm)	Reference
PAHs *Benzo(a)Anthracene	0.16	6-12	N/A	N/A
*Chrysene	0.19	6-12	N/A	N/A
*Benzo(b)Fluoranthene	0.14	6-12	N/A	N/A
*Benzo(k)Fluoranthene	0.07	6-12	N/A	N/A
*Benzo(a)Pyrene	0.14	6-12	0.12	CREG
*Arsenic	10.1*	0-6	15	RfDC child
*Lead	205	0-6	N/A	N/A
Manganese	445**	0-6	5000	RfDC child
Mercury	54.**	0-6	N/A	N/A
Antimony	5.4**	0-6	20	RfDC child
Zinc	83	0-6	N/A	N/A
Chromium	14.8	0-6	250	RfDC child

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database
** Indicates numerical value is an estimated quantity

Ref (1)

Groundwater

New monitoring wells were installed at six locations on Tank Farm Five (Figure 8). All six wells were installed in the overburden material at depths from 13 to 31 feet from ground surface. Groundwater samples were collected from all six of the wells at the site and analyzed for TCL and TAL parameters. In addition, seven of the previously installed wells were sampled and analyzed during this investigation. Four of the six wells were sampled and analyzed for TPH and lead. Samples from the remaining two monitoring wells were analyzed for TCL and TAL parameters and TPHs (1). Groundwater samples were collected on July 20, 1990. Semivolatile organic compounds that exceeded comparison values were 1,2-dichloroethene, 1,1,1-trichloroethane, and trichloroethene. Several inorganic compounds exceeded comparison values including beryllium, cadmium, arsenic, manganese, nickel, lead, chromium, and vanadium. The maximum concentrations of those contaminants and their respective comparison values are shown in Table 16.

Table 16. Maximum Contaminant Concentration in On-site Groundwater (Tank Farm Five)

Contaminant	Maximum Conc. (ppb)	Comparison Value (ppb)	Reference
1,2-Dichloroethene	630	200	RfDC child
1,1,1-Trichloroethane	190**	40	RfDC child
Trichloroethene	38	5	MCL
*Beryllium	10.2	0.0081	CREG
Cadmium	5	2	EMEG child
*Arsenic	265**	3	RfDC child
Manganese	4720	1000	RfDC child
Nickel	530	100	LTHA
*Lead	630	50	MCL
Chromium	384	50	RfDC child
Vanadium	108*	20	LTHA

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database
** Indicates numerical value is an estimated quantity

Ref (1)

Surface Water/Sediment

Sediment and surface water samples were collected from five locations along Gomes Brook (Figure 8) to determine if the brook was contaminated. Three samples were taken on site, one off site and upstream, and one off site and downstream at the mouth of the brook. The sediment samples were collected from the 0- to 1-foot interval. The surface water and sediment samples were analyzed for TPHs and lead. The sediment samples were also analyzed for PCBs. None of the surface water samples contained lead concentrations above the detection limit of 3 ppb. None of the surface water samples contained levels of TPH above the detection limit of 1 ppm. PCBs were not detected in the sediment samples. The highest lead concentration detected in an on-site sediment sample was 25.8 ppm. The highest TPH value reported for on-site sediment was 220 ppm (1).

Underground Storage Tanks

Oil samples were collected from each of the 11 USTs, and water samples were collected from all but one of the USTs. The samples were collected to evaluate closure alternatives for the USTs. The data were not considered in the selection of contaminants of concern. The only persons likely to be exposed to the compounds would be remediation workers. If proper safety precautions are taken during remediation, exposure will be eliminated.

Summary of On-site Contamination

A summary of on-site contamination found at each site, listed by classes of compounds, is shown in Table 17.

TABLE 17. SUMMARY OF CONTAMINANTS OF CONCERN AT NETC SITES

SITE NAME	SEDIMENT	SUBSURFACE SOIL	SURFACE SOIL	GROUND-WATER
MELVILLE NORTH LANDFILL	PAHs Metals	VOCs Semi-volatile compounds PAHs Pesticides PCBs Metals	PAHs PCBs Metals	VOCs Metals
MCALLISTER POINT LANDFILL		PAHs PCBs Semi-volatile compounds Metals	PAHs PCBs Metals	VOCs Metals
TANK FARM 4	Metals		PAHs Semi-volatile compounds Metals	Metals
TANK FARM 5	Metals	Metals	PAHs Metals	VOCs Metals
FIRE FIGHTING TRAINING AREA		VOCs PAHS Metals	PAHs PCBs Metals	VOCs PAHs Metals

C. Off-site Contamination

Old Fire Fighting Training Area

The only off-site samples were taken from one monitoring well upgradient of the Old Fire Fighting Training area. No sample values exceeded comparison values.

McAllister Point Landfill

Off-site surface soil samples were analyzed for TAL parameters. None of the reported levels exceeded comparison values. Off-site subsurface soil analyses showed no levels above comparison values. Manganese was detected in a an off-site groundwater sample (230,000 ppb); that concentration appears to be typical for the region. Typically, when groundwater quality in the NETC area is marginal, it is due to excessive amounts of manganese and iron (4).

Sediment/Mussels

Sediment and mussel samples were not taken at McAllister Point Landfill during Phase 1 of the RI. The latest data available comes from the Gould Island, McAllister Point, and Allen Harbor Sediment and Mussel Sampling Report (17). Sediment and mussel samples collected in 1983, 1984, and 1988 were analyzed for total PCBs and metals. None of the concentrations reported were of public health concern. The confirmation study report data indicated that metals are accumulating in sediments and mussels near McAllister Point Landfill. That statement is supported by comparison of sampling and analytical data with control station data. Current data will be needed to determine if metals continue to accumulate, and if concentrations are of public health concern.

Melville North Landfill

Off-site groundwater was sampled (MW-5) upgradient of Melville North Landfill. Contaminants that exceeded comparison values are arsenic, beryllium, chromium, and manganese. The maximum concentrations of those contaminants and their associated comparison values are listed in Table 18.

Table 18. Maximum Contaminant Concentration in Off-site Groundwater (Melville North Landfill)

Contaminant	Maximum Conc. (ppb)	Comparison Value (ppb)	Reference
*Beryllium	3.8	.0081	CREG
*Arsenic	22.4	3	RfDC child
Manganese	3600	1000	RfDC child
Chromium	121	50	RfDC child

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database

Ref (1)

<u>Sediment/Mussels</u>

Sediment and mussel samples were not taken at Melville North Landfill during Phase 1 of the RI. The latest data come from the confirmation study report. Sediment and mussel samples collected in 1983, 1984, and 1988 were analyzed for total PCBs and metals. None of the concentrations reported are of public health concern. Current data will be required to determine if metals accumulate, and if concentrations are of public health concern.

Tank Farm Four

Off-site samples at Tank Farm Four were obtained from groundwater, surface water, and sediment. Contaminants in excess of comparison values were detected in one sediment sample and one monitoring well sample. Groundwater contaminants include cadmium, manganese, and lead. The maximum concentrations and comparison values are listed in Table 19. Contaminants of concern in sediment samples adjacent to Tank Farm Four and their comparison values (if available) are shown in Table 20.

Table 19. Maximum Contaminant Concentration in Off-site Groundwater (Tank Farm Four)

Contaminant	Maximum Conc. (ppm)	Comparison Value (ppm)	Reference
Cadmium	8.5	2	EMEG-child
*Lead	136	50	MCL
Manganese	115000	1000	RfDC child

Ref (1)

Table 20. Maximum Contaminant Concentrations in Off-Site Sediment Samples Tank Farm Four

Contaminant	Maximum Conc. (ppm)	Depth (feet)	Comparison Value (ppm)	Reference
*Arsenic	21.1	0-1	15	RfDC child
*Lead	12100	0-1	N/A	N/A
Chromium	25.9	0-1	250	RfDC child

Ref (1)

Tank Farm Five

Off-site surface water and sediment samples were collected from Gomes Brook, upstream and downstream from Tank Farm Five. Concentrations exceeding comparison values were reported for sediment samples taken downstream of the site. The contaminants of concern are listed in Table 21.

Table 21. Maximum Contaminant Concentrations in Off-Site Sediment Samples - Tank Farm Five

Contaminant	Maximum Conc. (ppm)	Depth (feet)	Comparison Value (ppm)	Reference
PAHs *Benzo(b)fluoranthene	0.17**	0-1	N/A	N/A
*Chrysene	0.16**	0-1	N/A	N/A
*Lead	26**	0-1	N/A	N/A
Nickel	0.02**	0-1	N/A	N/A
*Arsenic	13.7	0-1	15	RfDC child
Chromium	11.9	0-1	250	RfDC child

N/A Comparison values not available
* Contaminants are Class A or B2 carcinogens per EPA IRIS database
** Indicates numerical value is an estimated quantity

Ref (1)

C. Quality Assurance and Quality Control

Validation of the analytical sample results for this project was completed by Environmental Standards Inc. (ESI) of Valley Forge, Pennsylvania. Data validation was conducted in accordance with requirements specified in EPA protocols and in Region I Data Validation Guidelines (1).

Areas under the laboratory's control and reviewed during the validation of organic data include the following: sample holding times, gas chromatography/mass (spectrometry) (GC/MS) tuning, instrument calibration, blank analysis, surrogate recovery, matrix/spike/matrix spike duplicates, internal standards (IS) performance, Target Compound List (TCL) compound identification, compound quantification and reported detection limits, tentatively identified compounds, system performance, and overall assessment of the data for usability.

The areas reviewed in the validation of inorganic data included the following: sample holding times instrument calibration and initial calibration verification, continuing calibration verification, contract required detection limit (CRDL) standards for atomic absorption (AA) and induced coupled plasma (ICP), initial and continuing calibration blank analysis, post-digested spike sample recovery analysis, ICP serial dilution analysis, graphite furnace AA QC analysis, quarterly verification of instrument parameter report, and sample result verification.

CDM Federal Programs Corporation (CDM FPC) is providing RI oversight to EPA Region I. As part of oversight activities during the spring and summer of 1990, CDM FPC accepted split samples from the Navy's contractor. Samples accepted by CDM FPC were analyzed for TCL and TAL parameters for organic and inorganic constituents (15). The data were considered in determining the contaminants of concern. When there was a discrepancy, the higher reported value was used.

D. Physical and Other Hazards

ATSDR observed no conditions at the NETC sites that would constitute a physical or other hazard.

PATHWAYS ANALYSIS

An environmental exposure pathway consists of the following five components: 1) a source of contamination; 2) an environmental medium in which the contaminants may be present or from which contaminants may migrate; 3) a point of human exposure; 4) a route of exposure such as inhalation, ingestion, or dermal absorption; and 5) a receptor population. Pathways are considered complete when all five components exist and there is evidence that people have been, are, or will be exposed to a contaminant. A pathway is potential when at least one of the five components is missing, but could exist. A pathway is eliminated when at least one of the five components is missing and will never exist. Past, present, and future exposure pathways are discussed in the Pathways Analysis section of this public health assessment.

A. Completed Exposure Pathways

A completed exposure pathway (surface soil) was identified at the Old Fire Fighting Training Area (Site 09).

Surface Soil Pathway

The source of contamination at the Old Fire Fighting Training Area could be of two origins. Past burning of oil/water mixtures has led to hydrocarbon-contaminated soils. The contamination could have resulted on the surface during the fire fighting training and on the subsurface through leaking pipes that carried the oil/water mixtures from a storage site to the training area. It is reported that much of the site was covered by fill before it was developed into a child care center/baseball field/picnic and playground area. There is no documentation on the source of the fill, which could have introduced contamination to the site.

This site is currently being used for multiple purposes (i.e., a baseball field, the Teddy Colbert Child Care Center, and a picnic/playground area. Children play outside (weather permitting) on the day care fenced playground and in the general area surrounding the day care center, which includes the mounds on the site. Surface soil would be a point of exposure to anyone using the site.

Contaminants of concern in surface soil include cadmium, copper, arsenic, lead, vanadium, antimony, manganese, chromium, PAHs, and PCBs. Generally, metals have an affinity for soil and organic compounds in soil, which diminishes their mobility. High or low soil pH values (basic or acidic soil) can cause metals to become mobile. Surface soil pH values at the site were in the neutral range. PAHs generally have very low solubility and therefore readily adsorb to organic carbon in soils. Contaminants in surface soils can migrate off site via surface runoff. Additionally, contaminants can move from surface soils via precipitation, percolating through the soil to the groundwater. Finally, users of the site can transport contaminants. Sorbed particulates in dust and soil can be transported via users' clothing, shoes, and bodies.

Exposure routes include ingestion of and dermal contact with contaminated surface soil. If climatic conditions cause the site to become exceedingly dry, inhalation may also be an exposure route.

Exposed populations include children and workers at the day care center. Currently, the day care center has 52 children ranging in age from infant to 5 years. Any families or personnel with access to the base or its recreation areas would also be a receptor population.

B. Potential Pathways

Table 22 is a list of all the potential exposure pathways. Following are discussions of each pathway.

Groundwater

<u>Melville North Landfill</u>

Disposal practices at this site have led to contamination of the groundwater with volatile and semivolatile organic compounds and metals. The site owners plan to develop this site into a marina. If a well was installed on site and the water used during construction for such purposes as dust control, concrete mixing, compaction, or equipment cleaning, workers could be exposed to contaminants through dermal contact and inhalation. If a well was installed as a drinking water source, people could be exposed through ingestion and dermal contact.

<u>Melville North Landfill, McAllister Point Landfill, Tank Farm Four and Tank Farm Five</u>

Groundwater from the sites is not currently being used as a potable source. However, if in the future the groundwater is developed as a source of drinking water, people could be exposed through ingestion and inhalation of, and skin contact with, contaminated water. Additionally, the groundwater at Tank Farms Four and Five flows toward surface water sources. Currently, it does not appear that the groundwater has caused surface water contamination; however, the potential remains for surface water to be contaminated in the future.

Surface Soil

Melville North Landfill, McAllister Point Landfill, Tank Farm Four, and Tank Farm Five

Surface soil at the sites has been contaminated with PAHs, other semivolatile organic compounds, PCBs, and metals. Although the areas are fenced, access is possible.

Persons trespassing on the sites could be exposed to contaminants through incidental ingestion, inhalation, and skin contact. If the Melville North Landfill is developed into a marina, people building the marina and subsequent users could also be exposed to contaminants.

Subsurface Soil

Melville North Landfill

Subsurface soil contaminants include PAHs, PCBs, and metals. Developing the site into a marina will undoubtedly require some excavation. Construction workers involved in earth-moving operations would be exposed to contaminated subsurface soil by way of incidental ingestion, inhalation, and skin contact. Any subsurface soil that was excavated and left on the surface would be an exposure point for users of the marina. Exposure could occur through inhalation of contaminated dust entrained in the air, as well as through ingestion and skin contact.

Sediment

Melville North Landfill, Tank Farm Four, and Tank Farm Five

Metal contaminants have been detected in the sediments of Gomes Brook at Tank Farm Five and of Normans Brook at Tank Farm Four. Both sites abut residential areas. If children play along the streams, they could be exposed to the contaminated sediments through skin contact and incidental ingestion.

The sediments of the wetlands area of Melville North Landfill have been contaminated with PAHs, semivolatile organic compounds, and metals. Any trespassers to the area could be exposed to the contaminants through skin contact and incidental ingestion.

Food Chain

Contamination of the food chain (biota) is possible through bioaccumulation of certain contaminants, such as PCBs and metals, in fish, shellfish, and on-site domestic animals (dairy cows). ATSDR has no current sampling data available to definitively assess such pathways; thus, the foodchain is considered to be a potential pathway.

Tank Farm Four

Sampling has determined there are a number of contaminants of concern in surface soil, sediment, and groundwater at Tank Farm four. Some of the compounds are Class A or B2 carcinogens. The area was used as grazing land for dairy cows from 1979-1992. Dairy cows are "indiscriminant feeders," consuming considerable amounts of surface soil and small gravel along with their food, primarily grasses. The average adult dairy cow has about 1-2 pounds (lbs) of sand and fine gravel in her stomach, along with occasional plastic and metal objects. It would be reasonable to assume that dairy cows might ingest a significant quantity of contaminated surface soil and sediment.

The Navy no longer leases the area to the dairy farm. During the lease period the milk was sold to a commercial dairy. No sampling data is available for the evaluation of this pathway. Therefore, if the dairy products were contaminated, only a small percent of the product consumed by an individual may be contaminated as a result of market dilution. Milk is regulated by the Food and Drug Administration.

All Sites

Edible species of fish and shellfish have been identified on and off site. Metals and PCBs are known to be bioaccumulated by fish and shellfish, particularly shellfish. Although most of the area is closed to commercial fishing, people who are unaware of the closure order or unwilling to comply, may continue recreational or subsistence fishing and shellfish gathering. A small area of the shoreline near Tank Farms Four and Five is not affected by the closure order; that may encourage residents to stray into closed areas, as well as to consume fish and shellfish with unknown contaminant concentrations. Consumption of fish and shellfish, therefore, is a potential pathway (past, present, and future).

TABLE 22. POTENTIAL EXPOSURE PATHWAYS

PATHWAY NAME	COMPOUNDS	EXPOSURE PATHWAY ELEMENTS					TIME	COMMENTS
		SOURCE	ENVIRONMENTAL MEDIA	POINT OF EXPOSURE	ROUTE OF EXPOSURE	EXPOSED POPULATION		
On-site Groundwater	VOCs Metals	All Sites	Groundwater	Contaminated Well	Ingestion Inhalation Dermal Contact	Users of proposed marina	Future	No current receptor population
On-Site Surface soil	PAHs Metals PCBs Semi-volatile compounds	Melville North McAllister Point Tank Farm 4 Tank Farm 5	Surface Soil	Surface Soil Contaminated Dust	Ingestion Inhalation Dermal Contact	Users of proposed marina Trespassers - especially children	Past Present Future	No current receptor population
On-Site Subsurface Soil	VOCs Semi-volatile compounds PAHs Pesticides PCBs Metals	Melville North	Subsurface Soil	Any subsurface soil in landfill area	Ingestion Inhalation Dermal Contact	Developers and subsequent users of marina	Future	No current receptor population
On-Site Sediment	PAHs Semi-volatile compounds Metals	Melville North Tank Farm 4 Tank Farm 5	Sediment	Wetlands Gomes Brook Normans Brook	Dermal Contact	Users of proposed marina Trespassers - especially children	Past Present Future	No current receptor population
Off-Site Biota	VOCs PAHs PCBs Metals	All Sites	Food Chain	Contaminated Shellfish	Ingestion	Persons unaware of or ignoring shellfishing restrictions	Past Present Future	No shellfish sampling data
Off-Site Sediment	Metals	Tank Farm 4 Tank Farm 5	Sediment	Gomes Brook Normans Brook	Dermal Contact	Children playing along streams	Past Present Future	Receptor population not confirmed

PUBLIC HEALTH IMPLICATIONS

The contaminants disposed (released) into the environment at NETC could be of public health concern and result in adverse health effects. However, for adverse health effects to occur, two principle criteria must be met: the exposure pathway must be completed and the exposure concentration sufficient to cause adverse health effects.

A release does not always result in exposure. A person is exposed to a contaminant only if they come in contact with it; exposure may occur by breathing, eating, or drinking a substance containing the contaminant, or by skin contact with a substance containing the contaminant. Several factors determine the type and severity of health effects associated with exposure to a contaminant. Such factors include the exposure concentration (how much); the frequency and/or duration of exposure (how long); the route or pathway of exposure (breathing, eating, drinking, or skin contact); and the multiplicity of exposure (combination of contaminants). Once exposure takes place, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed individual influence how the individual absorbs, distributes, metabolizes, and excretes the contaminant. Together, those factors and characteristics determine the health effects that may result from exposure to a contaminant.

ATSDR considers the previously described physical and biologic characteristics when developing health guidelines. Toxicological profiles prepared by ATSDR summarize chemical-specific toxicologic and adverse health effects information. Health guidelines, such as ATSDR's minimal risk level (MRL) and EPA's reference dose (RfD) and cancer slope factor (CSF) are included in the toxicological profiles. Those guidelines are used by ATSDR public health professionals to determine an individual's potential for developing adverse noncancer health effects and/or cancer from exposure to a hazardous substance.

Health guidelines provide a basis for comparing estimated exposures with concentrations of contaminants in different environmental media (soil, air, water, and food) to which people might be exposed. An MRL is defined as an estimate of the daily human exposure to a contaminant that is likely to be without an appreciable risk of adverse noncancer health effects over a specified duration of exposure (acute, $\leq$14 days; intermediate, 15-365 days; chronic > 365 days). Oral MRLs are expressed in units of mg/kg/day. MRLs are not derived for dermal exposure. The method for deriving MRLs does not include information about cancer; therefore, an MRL does not imply anything about the presence, absence, or level of cancer risk. An EPA RfD is an estimate of the daily exposure of the human population, including sensitive subpopulations, that is likely to be without appreciable risk of adverse noncancer health effects during a lifetime (70 years). For cancer-causing substances, EPA has established the cancer slope factor (CSF) as a health guideline. The CSF is used to determine the number of excess cancers expected from exposure to a contaminant. Health guidelines are generally considered to have uncertainty (nature of calculation), and therefore the health guidelines should not be viewed as a strict scientific boundary between what level is toxic and nontoxic.

To link a site's human exposure potential with health effects that may occur under site-specific conditions, ATSDR estimates human exposure to site contaminants from ingestion of different environmental media (18). The following relationship is used to determine the estimated exposure to the site contaminant:

$$ED = (C \times IR \times EF) / BW$$

ED = exposure dose (mg/kg/day)
C = contaminant concentration
IR = intake rate
EF = exposure factor
BW = body weight

ATSDR uses standard intake rates for ingestion of water and soil. The intake rate for drinking water is 2 L/day for adults and 1 L/day for children. For incidental ingestion of soil, the intake rate is 100 mg/day for adults, 200 mg/day for children, and 5000 mg/day for children with pica behavior (repeated ingestion of non-nutritive substances). Standard body weights for adults and children are 70 kg and 10 kg, respectively. The maximum contaminant concentration detected in a specific medium at a site is used to determine the estimated exposure; use of the maximum concentration results in an evaluation that is most protective of human health. When unknown, the biological absorption from environmental media (soil, water, etc.) is assumed to be 100%.

Individuals have been exposed to multiple contaminants from incidental ingestion of contaminated soil at NETC. However, data are very limited on the health effects of exposure to multiple contaminants. Those effects can be additive, synergistic (greater than the sum of the single contaminant exposures), or antagonistic (less than the sum of the single contaminant exposures). Also, simultaneous exposure to contaminants that are known or probable human carcinogens could increase the risk of developing cancer. ATSDR's evaluation of exposures in this public health assessment is limited to individual contaminant exposures; multiple exposures have not been evaluated.

A. Toxicologic Evaluation

The following sections evaluate the potential health effects of exposure to contaminants at NETC. The toxicologic evaluation of each contaminant assesses probable health effects associated with exposure to the contaminant. The health effects are related to contaminant concentration, exposure pathway, exposure frequency, and population exposed. Populations known or suspected to be sensitive to the contaminant are included in the evaluation. The Old Fire Fighting Training Area, the site at the installation identified as having a completed pathway of exposure, is discussed. The owners of the Melville North Landfill (which has been identified as a potential pathway) plan to develop it into a marina; therefore, current and future land use scenarios at that site are discussed. For additional chemical-specific toxicologic information, see Appendix B.

Old Fire Fighting Training Area (Site 09)

The Old Fire Fighting Training Area currently is the site of a children's day care center, picnic area, and a playground/ballfield. The day care center has operated at the site since 1982; it houses a maximum of 52 preschool-age children 5 days/week and has 12-16 employees. Populations potentially exposed in the area include children and workers at the day care center and persons using the recreational park. Exposure populations may include people who used the area in the past, use it now, or may use it in the future. Exposure may result from skin contact with and/or incidental ingestion of surface soil. The area is covered with grass; therefore, exposure is not expected via inhalation of dust.

The toxicologic evaluation of this area will focus on the exposure of children, particularly the subpopulation who may have pica behavior (repeated ingestion of non-nutritive substances). This subpopulation of children will be referred to as "pica children" throughout this evaluation. Children are a sensitive segment of the exposed population because their relative exposure (mg/kg) by incidental ingestion is greater than that of adults. Children with pica behavior have even greater exposure potential. The reported prevalence of pica behavior among children ages 1-5 years ranges from 16-18.5% (19-21). Approximately 23% of children with pica behavior are reported to ingest soil as the non-nutritive substance (19).

Estimated exposures will be determined using 7 days/week as the exposure frequency. Children routinely attend the day care center 5 days/week and play outside daily, weather permitting. The playground/ballpark may be used 7 days/week. Therefore, it is assumed that a child could attend the day care center during the week and play on the playground/ballpark on the weekend, resulting in daily exposure. Those assumptions will result in an overestimate of exposure for individuals who are not on site every day.

The contaminant concentrations used to estimate exposure are predominantly from one surface soil sample (SS 06). However, concentrations above comparison values were detected in other surface soil samples taken at the Old Fire Fighting Training Area. The maximum concentrations for all contaminants, except for cadmium and PCBs, are from surface soil sample #06. The sample was taken along the shoreline of the Old Fire Fighting Training Area and may be misleading as a representative sample of the exposure area (i.e., where children play).

Several samples in addition to the original sampling, have been taken from within the day care fenced playground (the most likely point of exposure for children at the day care center). However, the analysis was limited to metals; the samples were not evaluated for other compounds listed as contaminants of concern (PAHs and PCBs). Contaminants of concern identified in the surface soil at the Old Fire Fighting Training Area include metals, PAHs, and PCBs (Table 3).

Metals

Metals detected in the surface soil and listed as contaminants of concern at the Old Fire Fighting Training Area (Table 3) include antimony, arsenic, cadmium, chromium, copper, lead, manganese, and vanadium.

Antimony

Antimony was detected at a maximum concentration of 5.6 ppm in surface soil at the Old Fire Fighting Training Area. The estimated exposures from incidental ingestion of contaminated soil are 0.000008 mg/kg/day for adults, 0.0001 mg/kg/day for children, and 0.0028 mg/kg/day for pica children.

The estimated exposures of adults and children are less than the oral RfD of 0.0004 mg/kg/day (22). Therefore, exposures of adults and children to antimony are not of public health concern and are not expected to result in adverse, noncancer health effects.

The estimated exposure of pica children is above the RfD. The RfD is based on lifetime exposure, and exposure of pica children at the Old Fire Fighting Training Area would not be over a lifetime (a five-year exposure would be the maximum).

Adverse health effects associated with antimony reported in the literature are from much higher exposure doses than would be expected at the Old Fire Fighting Training Area. Antimony is used in several parasitic treatment regimens. Toxic side effects in people following treatment (injection) with antimony-containing drugs have been reported; those effects include altered EKG, anemia, vomiting, diarrhea, and joint and muscle pain. Altered EKG readings were observed after 4 days of trivalent antimony treatment (0.98 mg/kg/day); however, a change in readings was not observed until after 3 weeks of pentavalent injections (7.2 mg/kg/day) (23). Those exposure doses far exceed those expected for pica children at the Old Fire Fighting Training Area.

Medicinal treatments with antimony-containing drugs are usually injected, resulting in almost complete absorption. Although quantitative information on the absorption of antimony is not available for all forms of antimony, International committee on Radiation Protection has recommended the following reference values for gastrointestinal absorption in humans: 10% for antimony tartrate, and 1% for all other forms of antimony (23). Therefore, exposure by ingestion would result in a biologic exposure much less than an equal, injected dose. Therefore, it seems unlikely that incidental ingestion of antimony-contaminated soil at the Old Fire Fighting Training Area will result in adverse noncancer health effects.

There are no documented reports of health effects in people who have had skin contact with antimony (23).

No information was found on the cancer-causing potential of antimony in humans. Exposure to antimony did not produce cancer in rats or mice exposed orally (23).

Arsenic

Arsenic (unspeciated) was detected at a maximum concentration of 8.9 ppm in surface soil at the Old Fire Fighting Training Area. The daily estimated exposure to arsenic from incidental ingestion of soil is 0.00001 mg/kg/day for adults, 0.0002 mg/kg/day for children, and 0.0044 mg/kg/day for pica children.

The oral RfD for inorganic arsenic (the more toxic form of arsenic) is 0.0003 mg/kg/day (See Appendix B for discussion about chemical forms of arsenic) (22). A study in Taiwan of 17,000 people exposed to arsenic- contaminated drinking water determined that 0.0005 mg/kg/day was the no-effect level for humans (24). The daily estimated exposure of adults (0.00003 mg/kg/day) and children (0.0002 mg/kg/day) who ingest incidental amounts of soil at the Old Fire Fighting Training Area is below the RfD and the no-effect level. Therefore, no adverse noncancer health effects are expected in adults or children who ingest incidental amounts of arsenic-contaminated soil at the Old Fire Fighting Training Area.

Pica children ingest larger quantities of soil and, therefore, have a higher relative exposure to contaminants in soil. The estimated arsenic exposure of pica children at this site (0.0044 mg/kg/day) is greater than the Rfd and the no-effect level. Therefore, exposure of pica children to arsenic at the Old Fire Fighting Training Area could be of public health concern and could result in adverse noncancer health effects. It should be noted, however, that most noncancer effects associated with exposure to arsenic are observed at levels of chronic exposure, ranging from 0.01 to 0.1 mg/kg/day (24). The daily estimated exposure of pica children (0.0044 mg/kg/day) from incidental soil ingestion at the Old Fire Fighting Training Area is below that range. Therefore, noncancer health effects may be unlikely from ingestion of incidental amounts of arsenic-contaminated soil at the Old Fire Fighting Training Area.

Absorption of arsenic from skin contact with contaminated soil is usually considered to be minor (24). Therefore, skin contact with soil at the Old Fire Fighting Training Area is not expected to result in adverse health effects. Also, exposure by dermal contact should not significantly increase the total biologic exposure (dermal contact plus incidental ingestion).

The EPA has classified arsenic as a known human carcinogen. The main effect of oral exposure is increased risk of skin cancer. Some studies have indicated that ingestion of arsenic may increase the risk of internal tumors (liver, kidney, bladder, and lung) (24).

Skin cancers in people chronically exposed to 0.009-0.1 mg/kg/day arsenic in drinking water have been reported in the literature (24). The estimated exposure of adults (0.00001 mg/kg/day) from incidental ingestion of soil at the Old Fire Fighting Training Area is approximately 1000-fold less than those exposures. Therefore, exposure to arsenic-contaminated soil is not expected to result in cancer-related health effects in exposed adults at NETC.

The carcinogenic potential of arsenic appears to be linked to the duration, frequency, and concentration of exposure. Children who remain at the day care facility at the Old Fire Fighting Training Area for an extended period of time -- 1-5 years -- may fulfill those criteria. The estimated exposure of children (0.0002 mg/kg/day) is approximately 40-fold lower than the exposures that have been associated with skin cancers in humans (0.009-0.1 mg/kg/day), and the estimated exposure for pica children (0.0044 mg/kg/day) is approximately 2-fold less. However, those margins of safety may not be acceptable. The risk of early-life (childhood) exposure to carcinogens has not been fully evaluated. Therefore, exposures of children and pica children at the Old Fire Fighting Training Area are of public health concern and could result in cancer-related health effects.

Cadmium

Cadmium was detected at a maximum concentration of 0.94 ppm in surface soil at the Old Fire Fighting Training Area. The estimated exposure of adults in the area from incidental ingestion is 0.000001 mg/kg/day; for children, it is 0.00002 mg/kg/day; and for pica children, 0.0005 mg/kg/day.

The daily estimated exposures at the Old Fire Fighting Training Area for adults and children are below the chronic oral MRL of 0.0002 mg/kg/day (25). Therefore, adverse noncancer health effects from incidental ingestion of contaminated soil at the Old Fire Fighting Training Area are not expected in adults or children.

The estimated exposure of pica children (0.0005 mg/kg/day) at the Old Fire Fighting Training Area is greater than the chronic oral MRL (0.0002 mg/kg/day). However, adverse noncancer health effects are unlikely at this exposure concentration.

Renal dysfunction, manifested as impaired tubular reabsorption, is the primary toxic effect of chronic cadmium exposure. The dysfunction generally develops after cadmium reaches a minimum threshold level in the renal cortex. A total intake of approximately 2000 mg cadmium is the lifetime threshold for renal tubular damage (25). Assuming daily exposure for five years (maximum stay in the day care facility), the maximum intake of cadmium from incidental ingestion of soil by a pica child at the day care center would be 7.3 mg. That amount is approximately 0.4% of the lifetime threshold for renal tubular damage expected from exposure to cadmium. Therefore, exposure of pica children to cadmium at the Old Fire Fighting Training Area (day care center) would contribute minimally to the lifetime threshold, and renal tubular damage would not be expected from such exposures.

Absorption of cadmium through the skin is very slow (25). Therefore, exposure by skin contact is a minor route. Skin contact with surface soil at the Old Fire Fighting Training Area would not be expected to result in sufficient absorption to cause adverse health effects.

A few studies of cancer rates in people with oral exposures to cadmium have been conducted, and there is little evidence of an association between such exposure and increased cancer rates (25). However, the studies do not provide sufficient evidence to determine the carcinogenicity of cadmium by the oral route of exposure.

Several important factors affect biologic exposure to cadmium. Most ingested cadmium passes through the gastrointestinal tract without being absorbed (25). However, infants and children may have a higher rate of gastrointestinal absorption of cadmium than adults.

Mechanisms for maintaining the amount of cadmium absorbed from the gastrointestinal tract are not fully developed in infants and children. Cadmium absorption is also affected by nutritional factors. Low reserves of calcium, protein, and iron increase cadmium absorption and may increase risk of toxicity (25). Therefore, nutritionally deficient children may be at greatest risk of adverse health effects from ingestion of incidental amounts of cadmium-contaminated soil.

Chromium

Chromium was detected at a maximum concentration of 18.8 ppm in surface soil at the Old Fire Fighting Training Area. Estimated exposures by incidental ingestion are 0.00003 mg/kg/day for adults, 0.0004 mg/kg/day for children, and 0.0094 mg/kg/day for pica children.

Chromium is a naturally occurring element found in the environment in several forms. Chromium(III) occurs naturally and is an essential element for normal metabolism. Chromium(VI) is the most toxic form of chromium. The oral RfD for chromium(VI) is 0.005 mg/kg/day (22), compared with 1.0 mg/kg/day for chromium(III). For purposes of this public health implications evaluation, all chromium at the Old Fire Fighting Training Area is assumed to be chromium(VI). Using that assumption will ensure maximum protection to the public.

The estimated exposures of adults and children at the Old Fire Fighting Training Area are below the oral RfD for chromium(VI). Thus, exposure of adults and children to chromium in that area is not of public health concern, and adverse noncancer health effects are not expected.

However, the estimated exposure of pica children (0.0094 mg/kg/day) at the Old Fire Fighting Training Area is greater than the oral RfD (0.005 mg/kg/day) for chromium(VI). Therefore, exposure of pica children to chromium at the Old Fire Fighting Training Area is of public health concern. Due to degradation in the soil, it is unlikely that the chromium detected is predominantly chromium(VI). Therefore, adverse health effects are unlikely for pica children.

An important factor that influences conclusions about health effects associated with chromium exposure is the assumption that all chromium detected in the surface soil at the Old Fire Fighting Training Area is chromium(VI). Speciation of chromium would improve the evaluation of potential toxicity associated with chromium exposure.

Exposure to chromium at the Old Fire Fighting Training Area is not expected to result in cancer-related health effects in adults, children, or pica children. No cancer effects associated with people being exposed to chromium by ingestion or skin contact have been reported in the literature (26).

Copper

Copper was detected at a maximum concentration of 44.3 ppm in surface soil at the Old Fire Fighting Training Area. The estimated exposure from incidental ingestion of soil at this site is 0.0001 mg/kg/day for adults, 0.0009 mg/kg/day for children, and 0.0220 mg/kg/day for pica children.

Copper is an essential nutrient required by many enzymes for proper function. The National Academy of Science has recommended that 2-3 mg/day is a safe and adequate dietary intake for adults (27). Assuming 100% absorption from soil, the estimated exposure at the Old Fire Fighting Training Area of adults is less than 1% of the recommended daily intake, and the exposure of children is about 1% of the recommended intake. Therefore, the exposure of adults and children to copper in soil at the Old Fire Fighting Training Area is not expected to result in adverse noncancer health effects.

Adverse health effects associated with copper exposure have been reported in the literature. Vomiting and abdominal pain have been observed in individuals exposed via drinking water to 0.06 mg/kg/day of copper for approximately 1.5 years (27). Exposure of infants to 0.22-0.34 mg/kg/day of copper via drinking water for 9 months resulted in liver damage (27).

Assuming 100% absorption from ingested soil, the estimated copper exposure of pica children (0.0220 mg/kg/day) via incidental ingestion of soil at the Old Fire Fighting Training Area would be approximately 10-fold less than the water intake exposures that resulted in liver damage to infants, and approximately one-third the level known to cause adverse gastrointestinal effects. However, the margin of safety required to prevent adverse health effects as a result of copper exposure is unknown, especially for young children. Copper is readily absorbed from the stomach and small intestine (27). Children younger than one year are especially sensitive to copper exposure via ingestion because they have not developed the protective homeostatic mechanisms for clearing copper from the body and preventing its entry into the body from the intestine. Thus, exposure of pica children to copper at the Old Fire Fighting Training Area may be of public health concern and could result in adverse noncancer health effects.

A key limitation to this discussion of copper toxicity is that copper in soil is often bound to organic molecules; it is difficult to assess the toxicity of copper in soil because the available toxicity information is derived from episodes of exposure via drinking water. The bioavailability of the two media (soil and water) may not be comparable, resulting in different biologic exposures.

Because most copper deposited in soil is tightly bound to organic matter, bioavailability through dermal absorption is minimal (27). Therefore, dermal exposures at the Old Fire Fighting Training area are not expected to result in adverse noncancer health effects.

Studies have not reported an elevated incidence of cancer in people or animals exposed to copper via inhalation, ingestion, or skin contact (27). Therefore, exposure to copper-contaminated soil at the Old Fire Fighting Training Area is not expected to result in cancer-related health effects.

Populations that may be sensitive to copper include people with Wilson's disease, people with a deficiency of glucose-6-phosphate dehydrogenase, and children younger than one year. See Appendix B for a discussion of those populations.

Lead

Lead was detected at a maximum concentration of 77.8 ppm in surface soil at the Old Fire Fighting Training Area. The estimated exposures from daily incidental ingestion of soil are 0.0001 mg/kg/day for adults, 0.0016 mg/kg/day for children, and 0.0389 mg/kg/day for pica children.

Studies of people exposed to lead have not established concentrations in soil that result in blood lead concentrations associated with adverse noncancer health effects. Therefore, criteria for protecting public health have not been determined for lead-contaminated soil.

The National Academy of Science has established 3 mg/wk for adults and <3 mg/wk for children as the Acceptable Daily Intake (ADI) for lead (28). The daily estimated exposure of adults at the Old Fire Fighting Training Area is approximately 2% of the ADI. Therefore, exposure of adults in the area is not expected to result in adverse noncancer health effects.

Children are especially sensitive to lead toxicity. Because lead is ubiquitous in the environment, many children have elevated blood lead concentrations approaching those believed to cause adverse health effects (10 μg/dL) (28). As a result, any additional exposure to lead may be potentially harmful.

The daily estimated exposure of pica children is approximately equivalent to 3 mg/wk (the maximum ADI for children). Because lead is ubiquitous in the environment, children may also have daily intakes of lead from other sources. Those combination of exposures (other sources and day care) could result in daily intakes above the ADI. Therefore, exposure of pica children from daily incidental ingestion of lead-contaminated soil at the Old Fire Fighting Training Area may be of public health concern and could result in adverse noncancer health effects.

The daily intake of children from incidental ingestion of soil is only about 3% of the maximum ADI. However, the level of lead exposure from incidental soil ingestion at which adverse health effects are expected has not been determined. Therefore, the possibility of adverse health effects among children exposed at this site cannot be ruled out.

The most sensitive target of lead poisoning is the nervous system. Neurologic deficits caused by lead may be irreversible. The developing nervous system in children can be adversely affected at blood lead levels of less than 10 μg/dL. Effects of lead exposure in children include deficits in IQ score, cognitive function, psychometric intelligence scores, speech and language processing, attention span, hearing acuity, motor skills, reaction time, and hand-eye coordination (29).

The potential for exposure to lead from skin contact is considered insignificant because little lead passes through the skin (28). Therefore, adverse health effects of skin contact with lead- contaminated soil at the Old Fire Fighting Training Area are not expected.

Case reports have implicated lead as a potential renal carcinogen in people (28). EPA has concluded that human data are inadequate to determine the potential carcinogenicity of lead. However, using animal studies, EPA has classified lead as a probable human carcinogen. Criteria for determining possible cancer effects in people exposed to lead have not been established. Therefore, the cancer risk associated with lead exposure at the Old Fire Fighting Training Area cannot be evaluated.

Segments of the general population at highest risk of health effects from lead exposure are preschool-age children, pregnant women and their fetuses, and the elderly. Other susceptible people may include those with nutritional deficiencies, genetic diseases affecting heme synthesis, or kidney or neurologic dysfunction. Smoking cigarettes and drinking alcohol also may increase the risk of adverse health effects of lead exposure.

Manganese

Manganese was detected at a maximum concentration of 750 ppm in surface soil at the Old Fire Fighting Training Area. The estimated exposures from incidental ingestion of soil are 0.0011 mg/kg/day for adults, 0.015 mg/kg/day for children, and 0.375 mg/kg/day for pica children.

The Food and Nutrition Board of the National Research Council estimated the adequate and safe intake of manganese to be 2.5-5 mg/day and 0.7-1.0 mg/day for adults and for infants, respectively (30).

The estimated exposures for adults and children are less than the oral RfD of 0.1 mg/kg/day and below the recommended safe and adequate intake for manganese. Therefore, exposure to manganese at the Old Fire Fighting Training Area is not of public health concern and adverse noncancer health effects are not expected in adults or children.

The estimated exposure of pica children (0.375 mg/kg/day) is greater than the RfD and the recommended safe and adequate intake for manganese. Therefore, incidental ingestion of soil by pica children at the Old Fire Fighting Training Area is of public health concern and could result in adverse noncancer health effects.

Although the metallic element manganese is beneficial at low intake levels, high intake can cause adverse health effects. There is clear evidence that inhalation of manganese dusts in mines and factories can lead to manganism, a neurologic disorder that typically begins with feelings of weakness and lethargy and progresses to slow and clumsy gait, speech disturbances, a mask-like face, and tremors. Affected people may develop severe hypertonia and muscle rigidity and become permanently disabled. There is only limited evidence that oral exposure to manganese is of concern. However, several patients have reported similar symptoms after ingesting high levels of manganese (14 mg/L) in drinking water. The similarity of the effects seen with ingestion and inhalation exposures suggests that excess manganese intake by humans by those routes might lead to neurologic injury (30). However, those levels are more than 30-fold greater than the intakes expected for pica children via incidental ingestion of soil at the Old Fire Fighting Training Area.

Animal studies have also shown that exposure by ingestion may lead to neurologic effects. In those studies, a dose of about 980 mg/day (14 mg/kg/day) in an adult has been calculated as the neurological effect level (30).

It is generally considered that uptake across skin is very limited for most inorganic metal ions. Therefore, dermal exposure to manganese contaminated soil is not considered to be a health concern (30).

Data are not adequate to reach a conclusion about the carcinogenicity of manganese, but suggest that the potential for cancer in people is small (30).

Vanadium

Vanadium was detected at a maximum concentration of 36.3 ppm in surface soil at the Old Fire Fighting Training Area. The estimated exposure from incidental ingestion of contaminated soil is 0.00005 mg/kg/day for adults, 0.0007 mg/kg/day for children, and 0.0182 mg/kg/day for pica children.

The estimated exposures of adults and children are below the RfD for vanadium (0.007 mg/kg/day) (22). Therefore, adverse noncancer health effects are not expected in adults or children. The estimated exposure of pica children (0.0182 mg/kg/day) is greater than the RfD. However, several factors related to vanadium toxicity imply that it is not likely that pica children would experience adverse noncancer health effects. Vanadium is a naturally occurring element in soil; the average content in U.S. soils is 200 ppm (31), approximately 6-fold the levels detected at the Old Fire Training Area. People are not known to absorb large amounts of vanadium through the skin or gastrointestinal tract. The one clearly documented adverse health effect (respiratory irritation) in people results from inhalation of large amounts of vanadium dusts (31). For people to be at risk, large amounts of vanadium dusts would have to be present at the point of exposure. The grass cover at the Old Fire Fighting Training Area prevents this type of exposure. No other significant health effects of vanadium have been documented. The characteristics of vanadium suggest that the risk of toxicity in pica children who ingest incidental amounts of soil or have skin contact with vanadium-contaminated soil at the Old Fire Fighting Training Area is minimal.

Literature reports do not indicate that exposure to vanadium is associated with cancer. Workers exposed to vanadium dusts have not had increased mortality rates (although detailed studies have not been conducted) (31). Similarly, studies in animals have noted no increases in tumors associated with inhalation or oral exposure to vanadium (31). Therefore, exposure to vanadium-contaminated soil at the Old Fire Fighting Training Area is not expected to result in cancer-related health effects.

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are a class of compounds that may be carcinogenic and/or noncarcinogenic. The carcinogenic PAHs detected in surface soil at the Old Fire Fighting Training Area include benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, and benzo(a)pyrene. Noncarcinogenic PAHs include naphthalene and phenanthrene.

Because those PAHs are mixed together in the soil, and interaction among PAHs is common, the health effects of exposure to total PAHs are discussed. Using the maximum concentrations detected (SS-06) for individual PAHs, the total PAH soil concentration is 22.4 ppm, total carcinogenic PAH concentration is 14.8 ppm, and total noncarcinogenic PAH concentration is 7.6 ppm.

Daily exposure from incidental ingestion of PAHs in the surface soil would result in estimated exposures of 0.00003 mg/kg/day for adults, 0.0005 mg/kg/day for children, and 0.0121 mg/kg/day for pica children.

Safe limits for exposure to PAHs by ingestion have not been established. Therefore, adverse noncancer health effects of incidental ingestion of surface soil at the Old Fire Fighting Training Area cannot be quantitatively evaluated. However, adverse noncancer health effects associated with non-occupational PAH exposure generally have not been observed in people. Chronic dermatitis and hyperkeratosis have been seen in workers exposed to substances that contain PAHs. However, those exposures were much greater than those expected at the Old Fire Fighting Training Area. Therefore, exposure to the concentrations of PAHs in soil at the Old Fire Fighting Training Area is not expected to result in adverse noncancer health effects in adults, children, or pica children.

Absorption of PAHs from soil by skin contact is expected to be minimal. Studies of dermal absorption in people reported only 3% permeation of an applied dose of benzo(a)pyrene (a member of the PAH family of compounds) after 24 hours (32). Therefore, skin contact with PAH-contaminated soil at the Old Fire Fighting Training Area is not expected to result in adverse noncancer health effects.

Cancer is the most important endpoint of toxicity resulting from exposure to PAHs. See Appendix B for a discussion of those effects. Cancers associated with PAHs include skin, lung, urologic, gastrointestinal, laryngeal, and pharyngeal. Most information about cancer association comes from studies of occupational exposure. In general, occupational exposures are at much higher concentrations than the estimated exposures at the Old Fire Fighting Training Area.

Benzo(a)pyrene is considered to be one of the most carcinogenic forms of PAHs. Therefore, the potential for cancer-related health effects has been evaluated by adjusting the total carcinogenic PAHs detected at the Old Fire Fighting Training Area to an equivalent concentration of benzo(a)pyrene using toxicity equivalency factors (TEFs) (33). After adjustment with TEFs, the daily estimated exposure to carcinogenic PAHs is 0.000005 mg/kg/day for adults, 0.00007 mg/kg/day for children, and 0.002 mg/kg/day for pica children.

Using the EPA's cancer slope factor for benzo(a)pyrene (22), exposure of adults and children to carcinogenic PAHs by incidental ingestion of soil is not of public health concern, and cancer-related health effects are not expected. However, exposure of pica children to PAHs by incidental ingestion of soil at the Old Fire Fighting Training Area is of public health concern and could result in cancer-related health effects.

In general, PAHs can be converted enzymatically in the human body to less toxic substances (32). However, people with altered metabolic ability (increased Phase I enzymes, decreased Phase II enzymes, decreased efficiency of DNA-repair) may be more susceptible to the toxic effects of PAHs. Fetuses are particularly susceptible because of a decreased liver enzyme-conjugating function. People with deficiencies in vitamins A and C, iron, and riboflavin also may be at an increased risk for toxic effects related to PAHs. Smoking cigarettes and receiving excessive exposure to ultraviolet radiation (sunlight) are other factors that may result in increased sensitivity to PAH exposure.

Polychlorinated Biphenyls (PCBs)

Polychlorinated biphenyls were detected at a maximum concentration of 0.08 ppm in surface soil at the Old Fire Fighting Training Area. The daily estimated exposures for incidental ingestion of soil are 0.000001 mg/kg/day for adults, 0.000002 mg/kg/day for children, and 0.00004 mg/kg/day for pica children.

The daily estimated exposures of adults and children do not exceed the chronic MRL of 0.000005 mg/kg/day. Therefore, exposure by incidental ingestion of PCB-contaminated soil at the Old Fire Fighting Area is not expected to result in adverse noncancer health effects in adults and children.

The daily estimated exposure for pica children (0.00004 mg/kg/day) to PCBs in soil at the Old Fire Fighting Training Area exceeds ATSDR's chronic MRL (34). Therefore, their exposure to PCB-contaminated soil at the site is of public health concern and could result in adverse noncancer health effects.

Skin contact with PCB-contaminated soil can result in absorption of the contaminants (34). Exposure via both skin contact and incidental ingestion could result in an increased exposure (skin contact plus ingestion) to PCBs. In children, skin contact in addition to incidental ingestion can result in sufficient exposure to place them at risk for adverse noncancer health effects.

Chloracne, erythema, and skin rashes have been reported in people dermally exposed to PCB mixtures. Exposures which resulted in those effects were estimated to be in the range of 0.026-0.364 mg/kg/day. ATSDR does not estimate dermal exposure. However, dermal exposure at the Old Fire Training Area is expected to be much less than those reported to result in adverse dermal effects.

EPA has classified PCBs as a probable human carcinogen. However, using EPA's cancer slope factor, exposure to PCB-contaminated soil by incidental ingestion at the Old Fire

Fighting Training Area is not expected to result in cancer-related health effects in adults, children, or pica children.

Any additional exposure from skin contact with the soil is not expected to increase exposure enough to result in cancer-related health effects in those persons.

Melville North Landfill: Current Land Use

Contaminants of concern identified in surface soil, subsurface soil, groundwater, and sediments at Melville Landfill include PAHs (both carcinogenic and noncarcinogenic), metals, VOCs, and PCBs. The maximum concentration detected in a particular exposure medium will be used to evaluate a contaminant's toxicity. Scenarios involving current and future land use at Melville North Landfill will be discussed.

Under current land use conditions, individuals could be exposed to contaminants by incidental ingestion or by skin contact with contaminated surface soil or sediment from marshy areas. Inhalation of contaminated dust is not expected to be an exposure pathway because of the foliage cover and dampness of the site. Because of the landfill's location and current use, exposure to soils at the site is expected to be sporadic and infrequent. Adults and children may be exposed while trespassing on the site. Small children (6 months - 5 years) who may have pica behavior are not expected to be an exposure population at the landfill and will not be evaluated.

Contaminants detected in the surface soil and sediment include metals, PAHs, and PCBs; their concentrations are shown in Tables 9 and 11 in the Environmental Contamination and Other Hazards section of this report.

Metals

Metals detected in surface soil and sediment at Melville North Landfill and listed as contaminants of concern (Tables 9 and 11) include antimony, arsenic, barium, chromium, copper, lead, manganese, mercury, nickel, silver, vanadium, and zinc.

Estimated exposures of children and adults to antimony, barium, chromium, manganese, mercury, silver, and vanadium at the Melville North Landfill do not exceed ATSDR health guidelines. Also, those metals have not been determined to cause cancer in people. Therefore, exposure to those metals at Melville North Landfill is not of public health concern and is not expected to result in cancer-related or noncancer health effects in adults or children.

Arsenic, copper, lead, and zinc were also detected in surface soil and sediment at Melville North Landfill (Tables 9 and 11). Studies of people and/or animals have not established the concentrations of copper, lead, and zinc in various environmental media that may cause adverse noncancer health effects. Following is a brief discussion of each of the metals in relation to exposure at Melville North Landfill. See Appendix B for a more detailed toxicologic discussion.

Arsenic

Arsenic was detected at a maximum concentration of 28.3 ppm in surface soil at Melville North Landfill. The daily estimated exposures of children and adults to arsenic from incidental ingestion of soil are 0.00057 mg/kg/day and 0.00004 mg/kg/day, respectively. Daily exposures are not expected at Melville North Landfill, so actual exposures are expected to be lower.

A study in Taiwan of 17,000 individuals exposed to arsenic-contaminated drinking water determined 0.0005 mg/kg/day as the no-effect level (24). The oral RfD for inorganic arsenic (the more toxic form) is 0.0003 mg/kg/day. See Appendix B for a discussion of the toxicity of different forms of arsenic. The daily estimated exposure of adults at the landfill is below those values; therefore, no adverse noncancer health effects are expected in adults. The daily estimated exposure of children, however, is slightly above the no-effect level and approximately 2-fold greater than the RfD for inorganic arsenic. If it is assumed that the arsenic at Melville North Landfill is predominantly the inorganic form, and that people are exposed daily, incidental ingestion of soil by children could result in adverse noncancer health effects. However, because it is unlikely that children will be exposed to arsenic-contaminated soil at Melville North Landfill on a daily basis, adverse noncancer health effects are unlikely.

Absorption of arsenic from skin contact is usually considered to be minor. Therefore, skin contact with arsenic-contaminated soil at Melville North Landfill is not expected to result in adverse noncancer health effects in adults or children.

EPA has classified arsenic as a known human carcinogen (24). The carcinogenic potential of arsenic appears to be linked to exposure concentration, frequency of exposure, and duration of exposure (24). Low concentrations of arsenic are detoxified in the human body by the process of methylation. Considering those facts (low exposure concentration, frequency of exposure, duration of exposure, and potential for detoxification), it is not likely that adults and children exposed to arsenic-contaminated soil at the Melville North Landfill will have cancer-related health effects. Appendix B includes a discussion of the cancer-causing effects of arsenic.

Copper

Copper was detected at a maximum concentration of 135 ppm in surface soil at Melville North Landfill. The estimated exposures from incidental ingestion are 0.00019 mg/kg/day for adults and 0.0027 mg/kg/day for children.

Copper is an essential nutrient required for proper function of many enzymes in the body. The National Academy of Science has recommended that, for adults, 0.03-0.04 mg/kg/day is a safe and adequate dietary intake of copper (27). The estimated daily exposure of children (0.0027 mg/kg/day) to copper-contaminated soil at the Melville North Landfill is 10-fold less than the recommended value; estimated daily exposure of adults at the landfill (0.00019 mg/kg/day) is 100-fold less. Such exposures are expected to be infrequent (not on a daily basis), which would result in even lower estimated exposures. Current exposure to copper by incidental ingestion of contaminated soil at Melville North Landfill is not expected to cause adverse noncancer health effects in adults or children.

Most copper deposited in soil is tightly bound to organic matter and bioavailability through dermal absorption would be minimal (27). Current dermal exposures at Melville North Landfill are not be expected to cause adverse noncancer health effects in adults or children.

Potential trespassers could be exposed to copper by both ingestion of and skin contact with soils. Because exposures are infrequent and of short duration, multiple routes of exposure (ingestion and dermal contact) are not expected to result in adverse cancer or noncancer health effects.

EPA and IARC have not classified copper as a carcinogen; EPA considers copper a class D carcinogen, and IARC considers the metal class 3. Both classifications mean that copper is not classifiable as to human carcinogenicity (27). No elevated incidence of cancer has been reported in studies of people or animals exposed to copper by oral or dermal routes of exposure. No cancers were observed in animals exposed to 5-1000 mg/kg/day copper in their diets (27). Therefore, current exposures to copper at Melville North Landfill are not expected to cause cancer-related health effects in adults or children.

Populations that are sensitive to copper (have a different or enhanced response) include infants (homeostasis undeveloped), individuals with Wilson's disease, and individuals with glucose-6-phosphate dehydrogenase deficiency (27). Appendix B discusses specific details about those populations.

Lead

Lead was detected at a maximum concentration of 206 ppm in sediment at Melville North Landfill. The estimated exposures by daily incidental ingestion of contaminated soil are 0.00029 mg/kg/day for adults and 0.0041 mg/kg/day for children. Daily exposure is not expected at the landfill; therefore, actual exposures are expected to be lower.

Studies of people exposed to lead have not established the concentrations in soil that may cause blood lead concentrations associated with adverse, noncancer health effects. Therefore, criteria for protecting the public health have not been determined for lead-contaminated soil.

The National Academy of Science has established 3 mg/wk for adults and <3 mg/wk for children as the Acceptable Daily Intake (ADI) of lead (28). Assuming 100% absorption from soil, the daily estimated exposures of adults at the Melville North Landfill would be about 10% of the ADI. Because daily exposure is not expected, and 100% absorption from soil is not likely, exposures are actually less. Therefore, for adults, lead exposure from daily incidental ingestion of soil at Melville North Landfill is not expected to be of public health concern. Thus, adverse noncancer health effects are not expected for exposed adults.

Lead is ubiquitous in the environment, resulting in daily exposure via food, water, paint chips, etc. Because of those daily exposures, some children have elevated blood lead concentrations approaching those known to cause adverse health effects (10 μg/dL) (28). A threshold for toxic effects associated with lead exposure has not been established. The potential for children to be exposed to lead by multiple sources and routes can increase the accumulation of lead in their bodies and result in adverse health effects.

The current exposures of children at Melville North Landfill are expected to be infrequent. Such infrequent exposures (i.e., exposures of trespassers) should not result in adverse noncancer health effects. Still, access to the site should be restricted because more frequent exposure (daily) could result in elevated lead exposures in children and could increase the accumulation of lead in their bodies, possibly leading to adverse noncancer health effects.

Dermal exposure to lead is considered insignificant because little lead is absorbed through the skin. Therefore, adverse health effects from skin contact with lead-contaminated soil at Melville North Landfill are not expected in adults or children.

Lead has been classified by EPA as a probable human carcinogen (28). Although lead has been found to cause cancer in animals in laboratory studies, health guidelines for possible cancerous effects in people have not been established. Therefore, the cancer risk associated with lead exposures at Melville North Landfill cannot be evaluated.

Segments of the general population at highest risk of health effects from lead exposure are preschool-age children, pregnant women and their fetuses, and the elderly. Other susceptible persons may include those with nutritional deficiencies, genetic diseases affecting heme synthesis, or kidney or neurologic dysfunction. Smoking cigarettes and drinking alcohol may increase the risk of lead-related adverse health effects.

Zinc

Zinc was detected at a maximum concentration of 585 ppm in the sediment at Melville North Landfill. With current land use, the daily estimated exposures to zinc from incidental ingestion of soil are 0.0117 mg/kg/day for children and 0.00084 mg/kg/day for adults. Daily exposures are not expected at the Melville North Landfill, however, so actual exposures are expected to be lower.

Zinc is an essential nutrient required as a cofactor in many enzyme systems of the body. The recommended daily allowance (RDA) is 0.21 mg/kg/day (35). The RDA is 250-fold and 18-fold greater than the daily estimated exposures of adults and children, respectively, to zinc at Melville North Landfill. Zinc concentrations that cause adverse health effects are usually much higher than the RDA (see Appendix B for additional discussion). Thus, adverse noncancer health effects are not expected from current exposure (skin contact or incidental ingestion) to zinc-contaminated soil at Melville North Landfill.

The EPA has determined that zinc is not classifiable as to its human carcinogenicity (22). However, no reports of cancer caused by exposure of humans to zinc were found in a review of the literature.

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are a class of compounds that may be either carcinogenic or noncarcinogenic. The carcinogenic PAHs detected in sediment and surface soil at Melville Landfill include benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, and indeno(1,2,3-cd)pyrene. Noncarcinogenic PAHs found at the landfill include pyrene, benzo(ghi)perylene, and fluoranthene.

Because people are exposed to those PAHs as a mixture in the soil, and because interaction among PAHs is common, the health effects of exposure to total PAHs are discussed. Using the maximum concentration detected for individual PAHs, the total soil concentration of carcinogenic PAHs is 44.8 ppm; the total soil concentration of noncarcinogenic PAHs is 33.4 ppm.

Daily exposure by incidental ingestion to carcinogenic PAHs in soil at the landfill would result in estimated exposure doses of 0.0001 mg/kg/day for an adult and 0.0016 mg/kg/day for a child. Daily exposure is not likely; less frequent exposure would result in lower estimated exposures.

Because of the expected infrequency of exposure at the landfill, the pattern of exposure at the landfill is considered acute. PAHs generally have low acute toxicity to humans, and the estimated exposures of adults and children from incidental ingestion of soil at Melville North Landfill are less than the acute MRL (0.1 mg/kg/day) for PAHs. Therefore, acute adverse health effects are not expected. Safe limits on chronic ingestion of PAHs have not been established. Therefore, the potential for adverse noncancer health effects from incidental ingestion of surface soil cannot be quantitatively evaluated. However, adverse noncancer health effects associated with non-occupational PAH exposure generally have not been observed in people. Chronic dermatitis and hyperkeratosis have been seen in workers exposed to substances that contain PAHs. However, those exposures have been at much greater concentrations than those at Melville North Landfill. Therefore, exposures to the concentrations of PAHs in soil at the landfill are not of public health concern, and are not expected to result in noncancer adverse health effects in exposed adults and children.

Absorption of PAHs from dermal contact with soil is expected to be minimal. Studies using human skin reported only 3% permeation of an applied dose of benzo(a)pyrene (a member of the PAH family of compounds) after 24 hours (32). Therefore, skin contact with PAH-contaminated soil at Melville North Landfill is not expected to cause adverse noncancer health effects.

Cancer is the most important toxic endpoint of exposure to PAHs. Cancers associated with PAHs are skin, lung, urologic, gastrointestinal, laryngeal, and pharyngeal. Most information about cancer association comes from studies of occupational exposure. In general, occupational exposures are of much higher concentrations than the estimated exposures at Melville North Landfill. Cancer effects from the current exposure concentrations and frequency at Melville North Landfill are unlikely. See Appendix B for additional discussion of cancer effects.

Polychlorinated Biphenyls (PCBs)

Polychlorinated biphenyls were detected at a maximum concentration of 8.0 ppm in the surface soil at Melville North Landfill. The daily estimated exposures to PCBs by incidental ingestion of soil are 0.000011 mg/kg/day for adults and 0.00016 mg/kg/day for children. Daily exposure is not expected at Melville North Landfill, so actual exposures are expected to be lower.

The daily estimated exposures to PCBs at Melville North Landfill exceed ATSDR's chronic oral MRL (0.000005 mg/kg/day [34]) for both adults and children. Therefore, daily exposures of adults and children by incidental ingestion at the landfill is of public health concern. However, at less frequent exposures (once per week), noncancer adverse health effects are not expected in adults. In contrast, weekly exposures of children to PCB-contaminated soil at Melville North Landfill are of public health concern.

Skin contact with PCB-contaminated soil could result in absorption of the contaminant. ATSDR does not estimate dermal exposure; however, skin contact could result in exposure to PCBs at Melville North Landfill. Also, exposure via both skin contact and incidental ingestion could mean a greater exposure (dermal contact plus incidental ingestion) that could increase the risk of noncancer adverse health effects.

EPA has classified PCBs as probable human carcinogens. Using EPA's cancer slope factor, exposure to PCB-contaminated soil by incidental ingestion at Melville North Landfill is not expected to result in adverse cancer-related health effects in adults and children. Also, the additional exposure from skin contact with the soil is not expected to increase exposure enough to cause cancer-related health effects in adults and children.

Melville North Landfill: Proposed Land Use

The Melville North Landfill has been proposed for development as a marina. Because of the excavation that would be required during construction, workers and individuals using the future marina could be exposed to contaminants in surface soil, sediment, subsurface soil, and/or groundwater at Melville North Landfill. Therefore, the subsurface soil and groundwater are potential pathways for human exposure to toxic chemicals. In addition to the current pathways (incidental ingestion and dermal contact), if the grass cover is removed, exposures could result from inhalation of contaminated dusts. The groundwater at the site is contaminated, and any public use (e.g., wells for drinking water, construction, or irrigation) could result in exposure to contaminants.

In addition to the current potential exposure populations (children and adults), future exposed populations could include small children with pica behavior who are potentially more susceptible to toxins because of their increased relative exposures. In addition, exposure frequency may be daily for workers at and users of the marina.

Chemicals detected at Melville North Landfill that could be of public health concern in the future include PAHs, PCBs, VOCs, pesticides, and metals (Table 6). PCBs and dibenzofurans detected in the subsurface soil at Melville North Landfill would be of particular health concern. Children and women of childbearing age are more susceptible to the toxic effects of PCBs. Dibenzofurans in the soil could increase the toxicity of PCBs.

Toxicologic Evaluation Summary

Old Fire Fighting Training Area (Site 09)

Contaminants detected at the Old Fire Fighting Training Area do not pose an increased risk of adverse health effects for most adults. However, exposure of persons with a sensitivity for a specific chemical (see Appendix B) could result in adverse health effects in those individuals.

The population most at risk from exposure at the Old Fire Fighting Training Area is children. That exposure population includes the subpopulation of pica children who are susceptible to contaminants found in the soil because of their increased potential for exposure. Pica children have behavior that predisposes them to elevated exposures to site contaminants.

Contaminants of particular concern at the Old Fire Fighting Training Area include lead and cadmium. Children are especially susceptible to the toxic effects of those metals because of their greater gastrointestinal absorption of metals. Lead and cadmium are cumulative toxicants and are widespread in the environment (gasoline emissions, cigarette smoke, paint chips, etc.). Therefore, exposures of young children at the day care center to contaminated soil in the area could increase the accumulation of lead and cadmium in their bodies, and increase the likelihood that they will experience adverse health effects.

Other contaminants of concern include the carcinogens arsenic, PAHs, and PCBs. It is difficult to assess the potential health effects that may result from exposures to complex mixtures of chemicals. Although there exists considerable information on the toxicologic effects of specific chemicals, data on the effects of complex mixtures are very limited. Animal studies have shown that exposure to complex mixtures of carcinogens can increase the risk of cancer. PCBs have been shown to increase the carcinogenic potential of some PAHs (34). Arsenic has been shown to inhibit DNA repair mechanisms (24); therefore, it could increase the carcinogenic potential of compounds, such as PAHs, that initiate cancer by damaging DNA. Thus, it may be inferred that exposure to combinations of chemicals at the Old Fire Fighting Training could increase the risk of cancer in exposed individuals.

The Old Fire Fighting Training Area is of public health concern with regard to children who may be exposed to contaminants in soil there. The primary population of concern is the subpopulation of pica children. However, the conclusion is strongly driven by one environmental sample; the values used to estimate exposure are predominantly from a surface soil sample (SS 06) taken from along the shoreline of Narragansett Bay. That sample may not be representative of the area where children play at the Old Fire Fighting Training Area. Additional sampling to further characterize the exposure potential of children playing in that area is recommended.

Melville North Landfill (site 02)

Considering current land use, few adverse health effects are expected from chemical exposure at the Melville North Landfill. Daily exposure at the site to arsenic, lead, and PCBs may increase the risk of adverse health effects in exposed individuals. However, exposure at the site is expected to be infrequent, which should result in lower estimated exposures and no adverse health effects.

Future plans for the site include development of the area into a marina. That use of the land would increase exposure frequency and also expand the potentially exposed population to small children (including children with pica behavior), women of childbearing age and their fetuses, and elderly people. Those populations are often more susceptible to contaminant exposure. Development of the property could also change exposure concentrations. Contaminants in the subsurface soil and groundwater may become contaminants of concern. If Melville North Landfill is developed into a marina, the impact on public health from potential exposure scenarios may be of concern.

B. Health Outcome Data Evaluation

ATSDR reviews health outcome data when completed pathways have been identified; when the toxicologic evaluation indicates the likelihood of health outcomes; or when the community near the site has health concerns.

Vital statistics information for the NETC area was provided by the Rhode Island Department of Health for the years 1980, 1985, and 1988 (Appendix C). The rate of live births per 1000 population was similar in the three nearby municipalities of Middletown, Newport, and Portsmouth, and comparable to the state rate. The rate of low-birth-weight infants was much lower in Portsmouth than in Middletown, Newport, or the state. The overall death rate per 1000 population was lower in Middletown and Portsmouth compared with the state rate. The Newport death rate was similar to the state rate for all three years. Between 65-80% of the deaths in all three towns for each of the years examined were in the over-65 age group. Malignant neoplasms accounted for 23-27% of deaths in Middletown, Newport, Portsmouth, and the state of Rhode Island in all years evaluated with one exception. In 1980, malignant neoplasms accounted for 33% of deaths in Middletown. The occurrence of cancer and the death rate in the census tract is comparable to rates for the state of Rhode Island.

C. Community Health Concerns Evaluation

ATSDR has addressed each of the community concerns:

1. Residents are concerned about possible contamination of groundwater supplies.

Evaluation of groundwater flow trends associated with the NETC study areas shows a general trend at all sites of groundwater flow toward Narragansett Bay. No potable water sources (surface or well) were identified hydraulically downgradient of the NETC NPL sites.

2. Past workers at the landfills are concerned that a possible increased cancer rate may be attributed to exposure to contaminants in the landfills.

Cancer is not one disease, but many different diseases. Different types of cancer develop for different reasons. Cancer is the second leading cause of death in the United States, exceeded only by heart disease. Approximately one person in three will develop cancer in his or her lifetime (36). In general, cancers take between 20 and 40 years to develop. The state statistics for cancer deaths for the NETC area and the state of Rhode Island are similar. No information is available on the exposure status of individuals who worked at the landfills; therefore, the existing databases are not sufficient at this time to respond to the question about cancer incidence in landfill workers.

CONCLUSIONS

1. ATSDR has determined that the Navy Education and Training Center (NETC) is an indeterminate public health hazard. Possible exposures in the past and present have been identified, and available information suggests that future exposures are possible. Exposures of public health concern may have been taking place since 1982 when the day care center was established at the Old Fire Fighting Training Area. Future exposures of concern may occur at the Melville North Landfill which has been proposed for development into a marina.

2. ATSDR has identified one completed pathway at NETC (The Old Fire Fighting Training Area, Site 09). That area is currently the site of a day care center, playground, and ballfield and picnic area. Children and workers at the day care center and people using the playground/ballfield may be exposed by way of incidental ingestion of and skin contact with surface soil at this site. Contaminants of concern include lead, cadmium, arsenic, PCBs, and PAHs. Infrequent exposures at the site are not of public health concern. However, daily exposures (especially of children with pica behavior) are of public health concern.

3. Conclusions about the health implications of exposure at the Old Fire Fighting Training Area are influenced by data from one environmental surface soil sample (SS 06). This sample was taken from an area along the shoreline of Narragansett Bay, and may not be representative of the area children use while playing. Data from that sample have had a significant impact on the health conclusions for this site.

4. ATSDR has determined that the proposed development of the Melville North Landfill into a marina is a potential public health concern. That use would increase the frequency of exposure; daily exposures could be expected for marina workers and frequent users of the facility. Also, the potential exposed populations would be expanded to include small children and other sensitive populations (pregnant women and their fetuses, and elderly people) not currently considered potential exposure populations.

5. Development of Melville North Landfill into a marina could change the exposure concentrations of the contaminants of concern. Excavation and construction at the site could expose subsurface contaminants, changing the public health impact. If the development takes place as planned, potential future exposures will need to be evaluated for possible health implications.

6. The community expressed concern about potential contamination of groundwater. The contaminated groundwater flow is toward Narragansett Bay and downgradient from drinking water sources. However, future development of the contaminated areas and use of on-site groundwater for drinking water could be a potential public health concern.

7. The community concern that the incidence of cancer among workers at the landfills may be related to exposure to contaminants in the landfills cannot be answered with the available information. The workers at the landfills are a small subset of the census tract population. A health outcome in a small subset, such as landfill workers, cannot be evaluated from statistics for an entire census tract. In addition, estimated exposures cannot be determined due to lack of environmental data.

8. Potential exposure pathways associated with contaminated biota cannot be adequately evaluated at this time. The potential exists for shellfish in the bay to be contaminated. The potential for contamination of shellfish requires further characterization.

RECOMMENDATIONS

1. Reduce the daily exposure of children with pica behavior at the day care center (Old Fire Fighting Training Area). Day care providers should be educated to recognize children with pica behavior and how to reduce the child's exposure. Also, an uncontaminated soil cover should be added to play area(s) that are identified as contaminated.

2. Further characterize the surface soil at the Old Fire Fighting Training Area. Samples from the site were obtained from 0-6 inches. ATSDR defines surface soil samples as 0-3 inches. Grab samples (0-1 inch) may also give a better indication of the exposures of children playing in the area. Sampling numbers should be adequate to fully assess the contamination and exposure potential at the day care center.

3. Limit access to Melville North Landfill. Frequent exposures to trespassers at the site could be of public health concern.

4. Sample shellfish and mussels in Narragansett Bay. Shellfishing is permitted along the coastline of NETC in the area of Tank Farms Four and Five. Current plans for shellfish sampling do not include the areas of coastline near Tank Farms Four and Five. Sediments from brooks in those areas are contaminated, which could lead to contamination being transported to the bay. Shellfish and mussel sampling is needed to evaluate the potential for biota contamination in those areas.

5. Speciate chromium into chromium (III) and chromium (VI). The toxicity of chromium is species specific. Speciation is necessary for comprehensive evaluation of adverse health effects.

6. Remediate Melville North Landfill before it is developed into a marina.

7. Evaluate the public health implications of future use of sites at NETC before they are developed. Increased frequency of exposure at the sites as a result of development could cause exposures of public health concern.

8. Provide personal protection to remedial workers in accordance with OSHA regulations and NIOSH guidelines at all sites.

The data and information developed in the NETC public health assessment have been evaluated by the ATSDR Health Activities Recommendation Panel (HARP) for follow-up health actions. The available data indicate that children, particularly those with pica behavior, may be exposed to levels of PAHs, PCBs, and metals in the surface soil at the Teddy Colbert Day Care Center that are of public health concern. However, the data used to determine the concentrations of contaminants to which children may be exposed is inconclusive.

Therefore, until exposure concentrations are better defined, measures to prevent possible adverse exposures are needed. Health education for day care workers about prevention of exposure and recognition of pica behavior is indicated. Recognition of this behavior and action to prevent possible exposures will be instrumental in prevention and mitigation of adverse health effects which may result from exposure to the surface soil.

If additional information becomes available indicating that humans are being exposed to levels of toxic substances that could cause harm, ATSDR will reevaluate the site for needed public health actions.

PUBLIC HEALTH ACTIONS

In accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, the data and information reviewed for NETC will be evaluated for public health actions.

The public health action plan (PHAP) for NETC describes actions planned by ATSDR and/or the Navy following completion of the public health assessment. The purpose of the PHAP is to ensure that this public health assessment not only identifies public health hazards, but provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included, is a commitment on the part of ATSDR to follow up on this plan to ensure that it is implemented. The public health actions to be implemented by ATSDR are as follows:

1. ATSDR will coordinate with Navy and state agencies to develop a PHAP for this site to evaluate implementing the site recommendations.

2. NETC will collect surface soil samples (approximately twelve) specifically from the 0 to 3 inch depth at the Old Fire Fighting Training Area. Those samples will be collected to reflect representative areas where the children play. Samples will be analyzed for inorganics, PCBs, and PAHs.

3. ATSDR will provide an annual follow up to this PHAP, outlining the actions completed and those in progress. This report will be placed in repositories that contain copies of this health assessment, and will be provided to persons who request it.

ATSDR will reevaluate and expand the Public Health Action Plan when needed. New environmental, toxicological, or health outcome data, or the results of implementing the above proposed action may determine the need for additional actions at this site.

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GLOSSARY OF ABBREVIATIONS

ADI	Acceptable Daily Intake
ATSDR	Agency for Toxic Substances and Disease Registry
CREG	Cancer Risk Evaluation Guide
CS	Confirmed Site
DCA	Dichloroethane
DCE	Dichloroethene
DHS	Department of Health Services
DWHA	Drinking Water Health Advisory
EMEG	Environmental Media Evaluation Guide
EPA	Environmental Protection Agency
GWTF	Groundwater Task Force
HAC	Health Assessment Comparison Value
HARP	Health Activities Recommendation Panel
ICRP	International Committee on Radiation Protection?
IRP	Installation Restoration Project
IWTP	Industrial Wastewater Treatment Plant
MCL	Maximum Risk Level
MCLG	Maximum Risk Level Goal
mg	Milligram
MRL	Maximum Risk Level
MW	Monitoring Well
NPL	National Priorities List
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene
PHA	Public Health Assessment
PMCL	Proposed Maximum Risk Level
ppb	Parts Per Billion
ppm	Parts Per Million
PRL	Potential Release Location
RDA	Recommended Daily Allowance
RfC	Reference Concentration
RfD	Reference Dose
RfDC	Reference Dose Concentration
SA	Study Area
TAL	Target Analyte List
TCA	Trichloroethane
TCE	Trichloroethene
TCL	Target Compound List
TPH	Total Petroleum Hydrocarbons
USGS	United States Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compound

APPENDIX A

Figures and Tables

US EPA CONTRACT LABORATORY PROGRAM TARGET COMPOUND LIST

VOLATILE ORGANIC COMPOUNDS
CHLOROMETHANE
BROMOMETHANE
VINYL CHLORIDE
CHLOROETHANE
METHYLENE CHLORIDE
ACETONE
CARBON DISULFIDE
1,1-DICHLORETHENE
1,1-DICHLORETHANE
1,2-DICHLORETHENE(total)
CHLOROFORM
1,2-DICHLORETHANE
2-BUTANONE
1,1,1-TRICHLOROETHANE
CARBON TETRACHLORIDE
VINYL ACETATE
BROMODICHLOROMETHANE
1,2-DICHLOROPROPANE
cis-1,3-DICHLOROPROPENE
TRICHLOROETHENE
DIBROMOCHLOROMETHANE
1,1,2-TRICHLOROTHANE
BENZENE
trans-1,3-DICHLOROPROPENE
BROMOFORM
4-METHYL1-2-PENTANONE
2-HEXANONE
TETRACHLOROETHENE
1,1,2,2-TETRACHLOROETHANE
TOLUENE
CHLOROBENZENE
ETHYLBENZENE
STYRENE
XYLENE(total)

BASE NEUTRAL/ACID EXTRACTABLES
PHENOL
bis(2-CHLOROETHYL)ETHER
2-CHLOROPHENOL
1,3-DICHLOROBENZENE
1,4-DICHLORBENZENE
BENZYL ALCOHOL
1,2-DICHLOROBENZENE
2-METHLYPHENOL
bis(2-CHLOROISOPROPYL)ETHER
4-METHYLPHENOL
N-NITROSO-D-N-PROPYLAMINE
HEXACHLOROETHANE
NITROBENZENE
ISOPHORONE
2-NITROPHENOL
2,4-DIMETHYLPHENOL
BENZOIC ACID
bis(2-CHLOROETHOXY)METHANE
2,4-DICHLOROPHENOL
1,2,4-TRICHLOROBENZENE
NAPHTHALENE(*)
4-CHLOROANILINE
HEXACHLOROBUTADIENE
4-CHLORO-3-METHYLPHENOL
2-METHYLNAPHTHALENE(*)
HEXACHLOROCYCLOPENTADIENE
2,4,6-TRICHLOROPHENOL
2,4,5-TRICHLOROPHENOL
2-CHLORONAPHTHALENE(*)
2-NITROANILINE
DIMETHYLPHTHALATE
ACENAPHTHYLENE(*)
2,6-DINITROTOLUENE
3-NITROANILINE
ACENAPHTHENE(*)
1,4-DINITROPHENOL
4-NITROPHENOL
DIBENZOFURAN
2,4-DINITROTOLUENE
DIETHYLPHTHALATE
4-CHLOROPHENYL-PHENYLETHER
FLUORENE(*)
4-NITROANILINE
4,6-DINITRO-2-METHYLPHENOL
N-NITROSODIPHENYLAMINE
4-BROMOPHENYL-PHENYLETHER
HEXACHLOROBENZENE
PENTACHLOROPHENOL
PHENANTHRENE(*)
ANTHRACENE(*)
DI-n-BUTAYLPHALATE
FLUORANTHENE(*)
PYRENE(*)
BUTYLBENZLPHTHALATE
3,3'-DICHLOROBENZIDINE
BENZO(a)ANTHRACENE(*)
CHRYSENE(**)
bis(2-ETHYLHEXYL)PHTHALATE
DI-n-OCTYLPHTHALATE
BENZO(b)FLUORANTHENE(**)
BENZO(k)FLUORANTHENE(**)
BENZO(a)PYRENE(**)
INDENE(1,2,3-cd)PYRENE(**)
DIBENZO(A,H)ANTHRACENE(**)
BENZO(g,h,i)PERYLENE(**)

PESTICIDE/PCB
ALPHA-AHC
BETA-BHC
DELTA-BHC
GAMMA-BHC(LINDANE)
HEPTACHLOR
ALDRIN
HEPTACHLOR EPOXIDE
ENDOSULFAN I
DIELDRIN
4,4-DDE
ENDRIN
ENDOSULFAN II
4,4-DDD
TOXAPHENE
ENDOSULFAN SULFATE
4,4-DDT
METHOXYCHLOR
ENDRIN KETONE
ALPHA-CHLORDANE
GAMMA-CHLORDANE
AROCHLOR-1016
AROCHLOR-1021
AROCHLOR-1232
AROCHLOR-1242
AROCHLOR-1248
AROCHLOR-1254
AROCHLOR-1260

TARGET ANALYTE LIST - METAL ELEMENTS
ALUMINUM
ANTIMONY
ARSENIC
BARIUM
BERYLLIUM
CADMIUM
CALCIUM
CHROMIUM
COBALT
COPPER
IRON
LEAD
MAGNESIUM
MANGANESE
MERCURY
NICKEL
POTASSIUM
SELENIUM
SILVER
SODIUM
THALLIUM
VANADIUM
ZINC

OTHER INORGANIC ELEMENTS

CYANIDE

(*) - Compound is a polycyclic aromatic hydrocarbon (PAH).
(**) - Compound is considered a carcinogenic PAH.

Table 18. ATSDR Public Health Hazard Conclusion Categories

Category	Definition	Criteria
A. Urgent public health hazard	This category is used for sites that pose an urgent public health hazard as the result of short-term exposures to hazardous substances.	• evidence exists that exposures have occurred, are occurring, or are likely to occur in the future **AND** • estimated exposures are to a substance(s) at concentrations in the environment that, upon **short-term exposures**, can cause adverse health effects to any segment of the receptor population **AND/OR** • community-specific health outcome data indicate that the site has had an adverse impact on human health that requires rapid intervention **AND/OR** • physical hazards at the site pose an imminent risk of physical injury
B. Public health hazard	This category is used for sites that pose a public health hazard as the result of long-term exposures to hazardous substances.	• evidence exists that exposures have occurred, are occurring, or are likely to occur in the future **AND** • estimated exposures are to a substance(s) at concentrations in the environment that, upon **long-term exposures**, can cause adverse health effects to any segment of the receptor population **AND/OR** • community-specific health outcome data indicate that the site has had an adverse impact on human health that requires intervention
C. Indeterminate public health hazard	This category is used for sites with incomplete information.	• limited available data do not indicate that humans are being or have been exposed to levels of contamination that would be expected to cause adverse health effects; data or information are not available for all environmental media to which humans may be exposed **AND** • there are insufficient or no community-specific health outcome data to indicate that the site has had an adverse impact on human health
D. No apparent public health hazard	This category is used for sites where human exposure to contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.	• exposures do not exceed an ATSDR chronic MRL or other comparable value **AND** • data are available for all environmental media to which humans are being exposed **AND** • there are no community-specific health outcome data to indicate that the site has had an adverse impact on human health
E. No public health hazard	This category is used for sites that do not pose a public health hazard.	• no evidence of current or past human exposure to contaminated media **AND** • future exposures to contaminated media are not likely to occur **AND** • there are no community-specific health outcome data to indicate that the site has had an adverse impact on human health

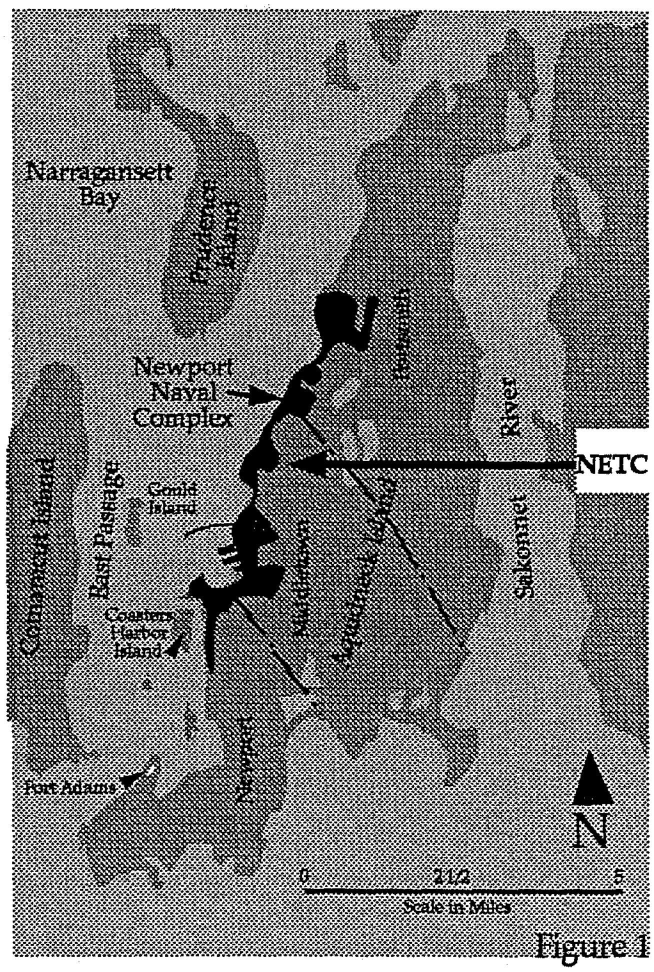


Figure 1

Naval Education and Training Center Vicinity Map

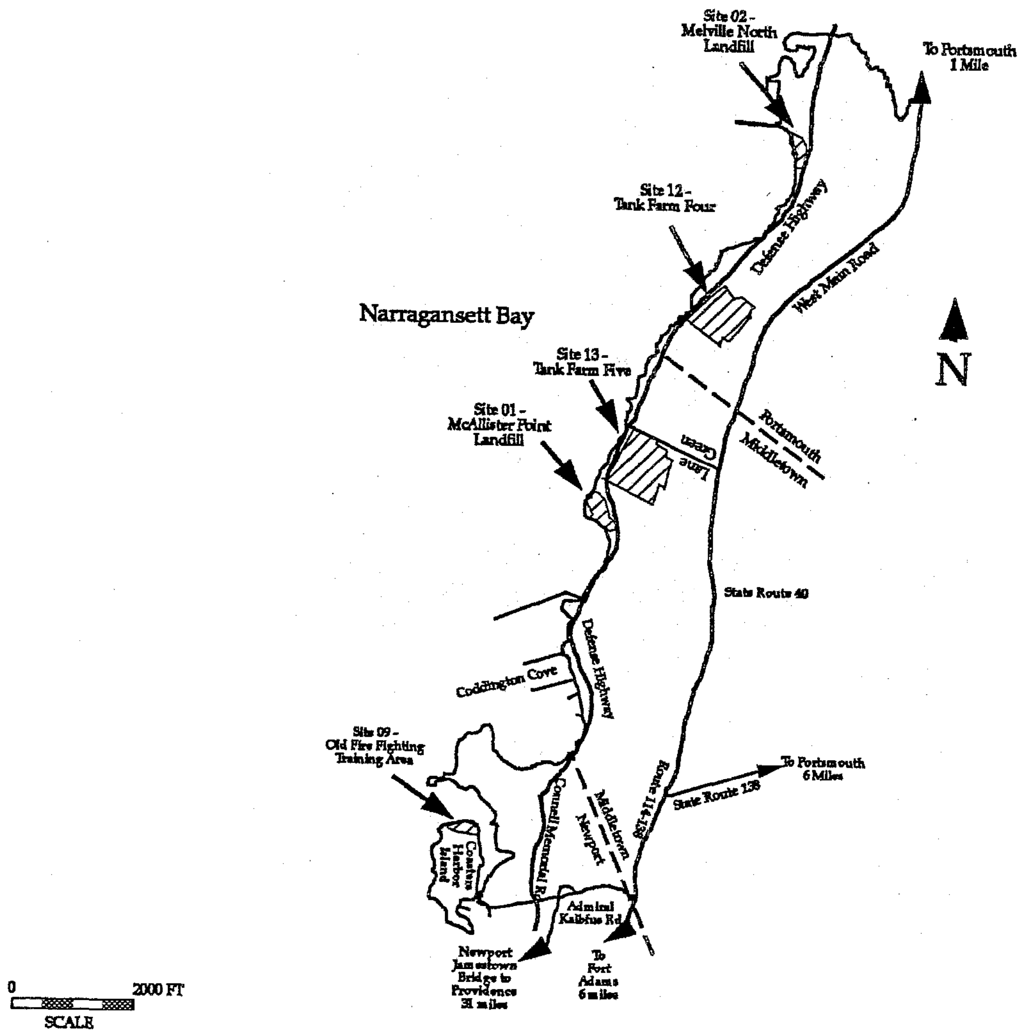


Figure 2

NETC Site Location Map

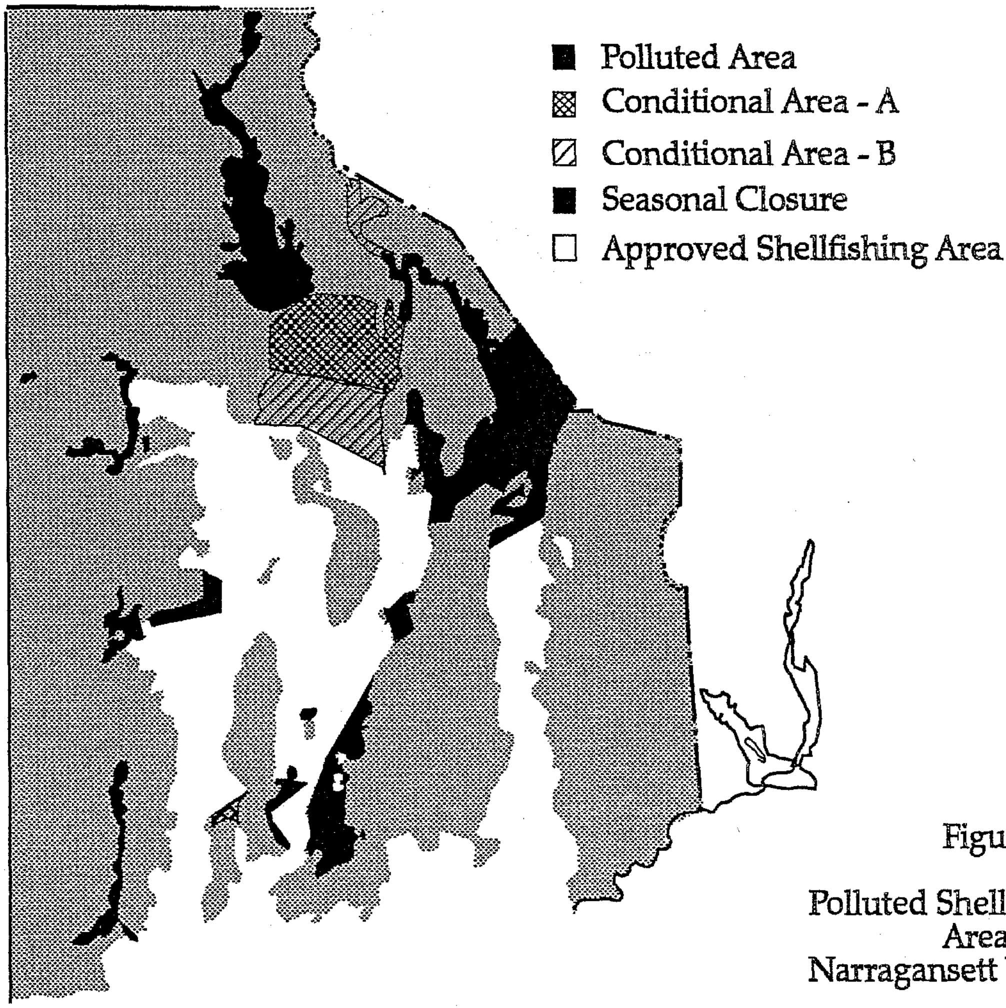


Figure 3

Polluted Shellfish Areas in Narragansett Bay

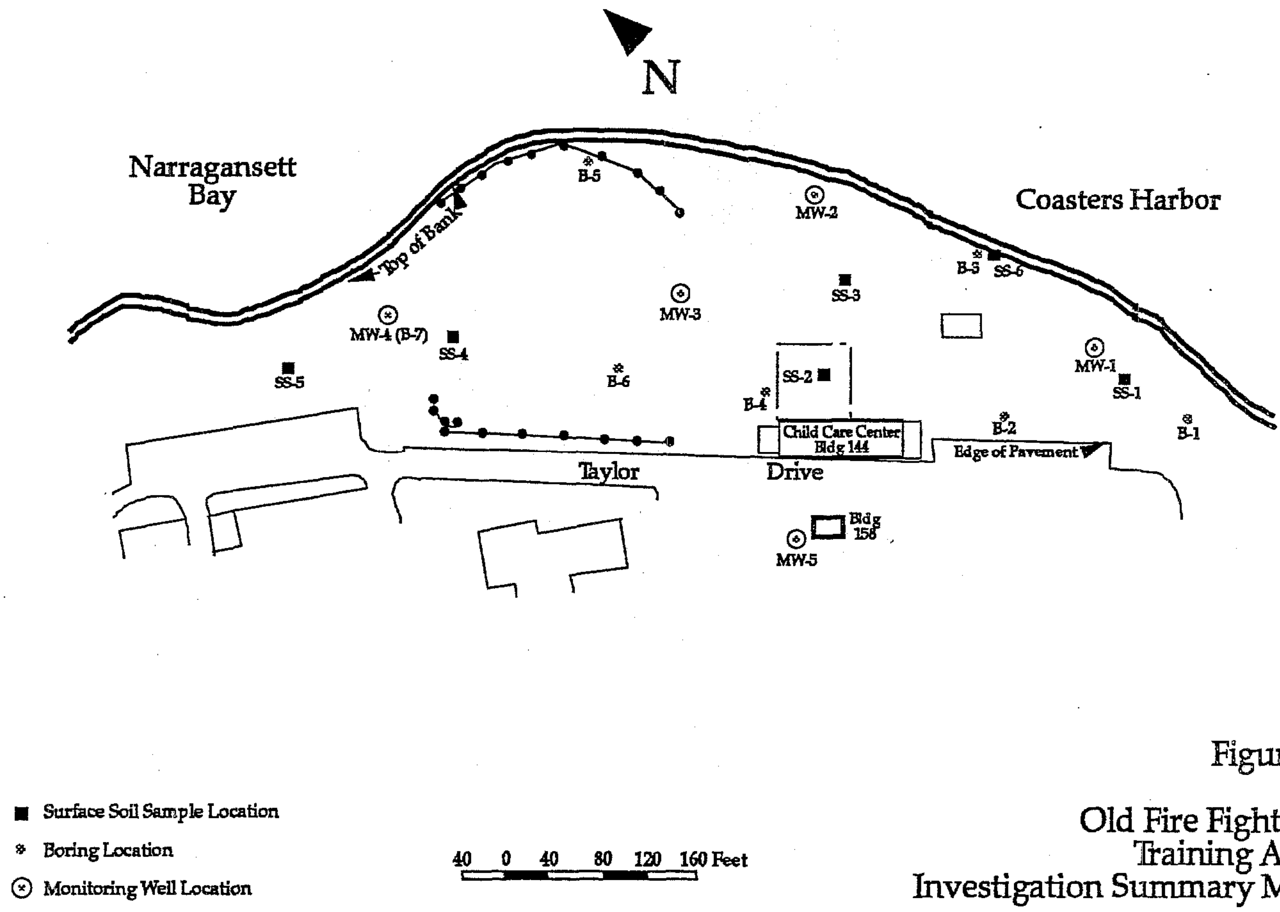


Figure 4

Old Fire Fighting Training Area Investigation Summary Map

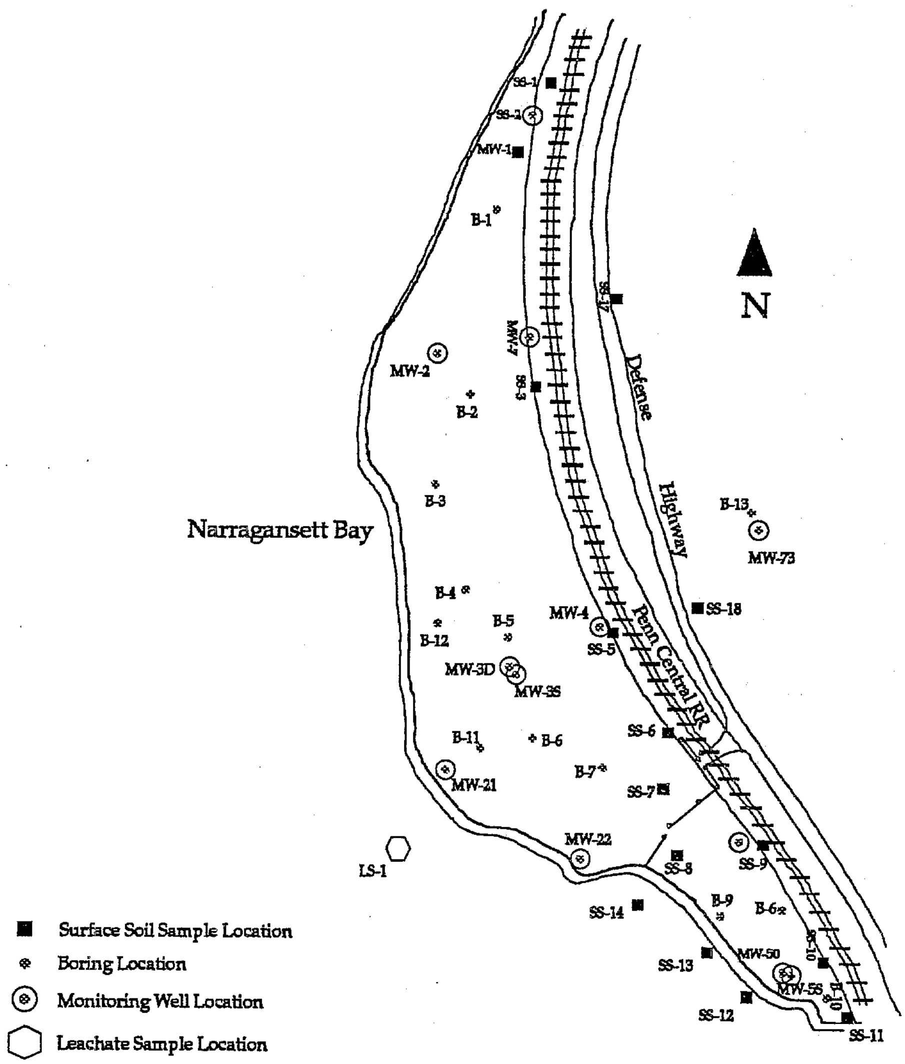


Figure 5

McAllister Point Landfill
Investigation Summary Map

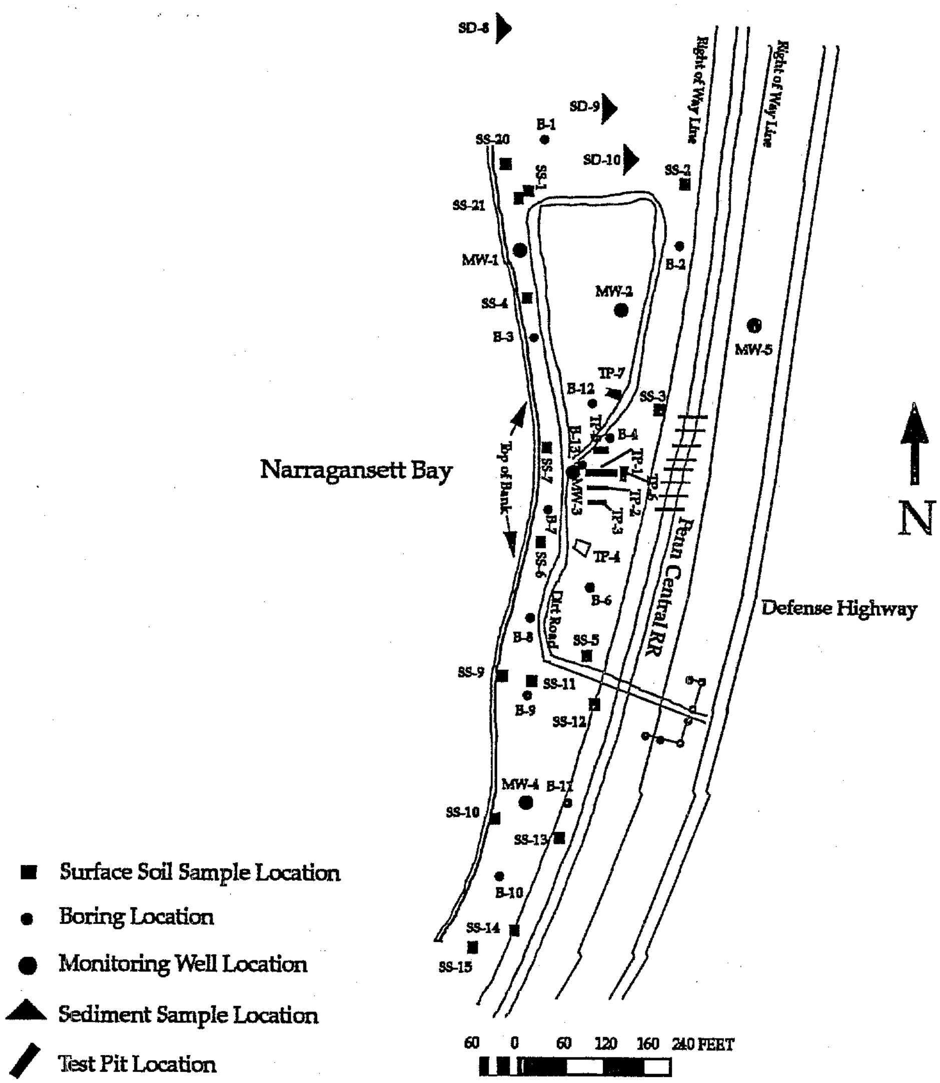


Figure 6

Melville Landfill
Investigation Summary Map

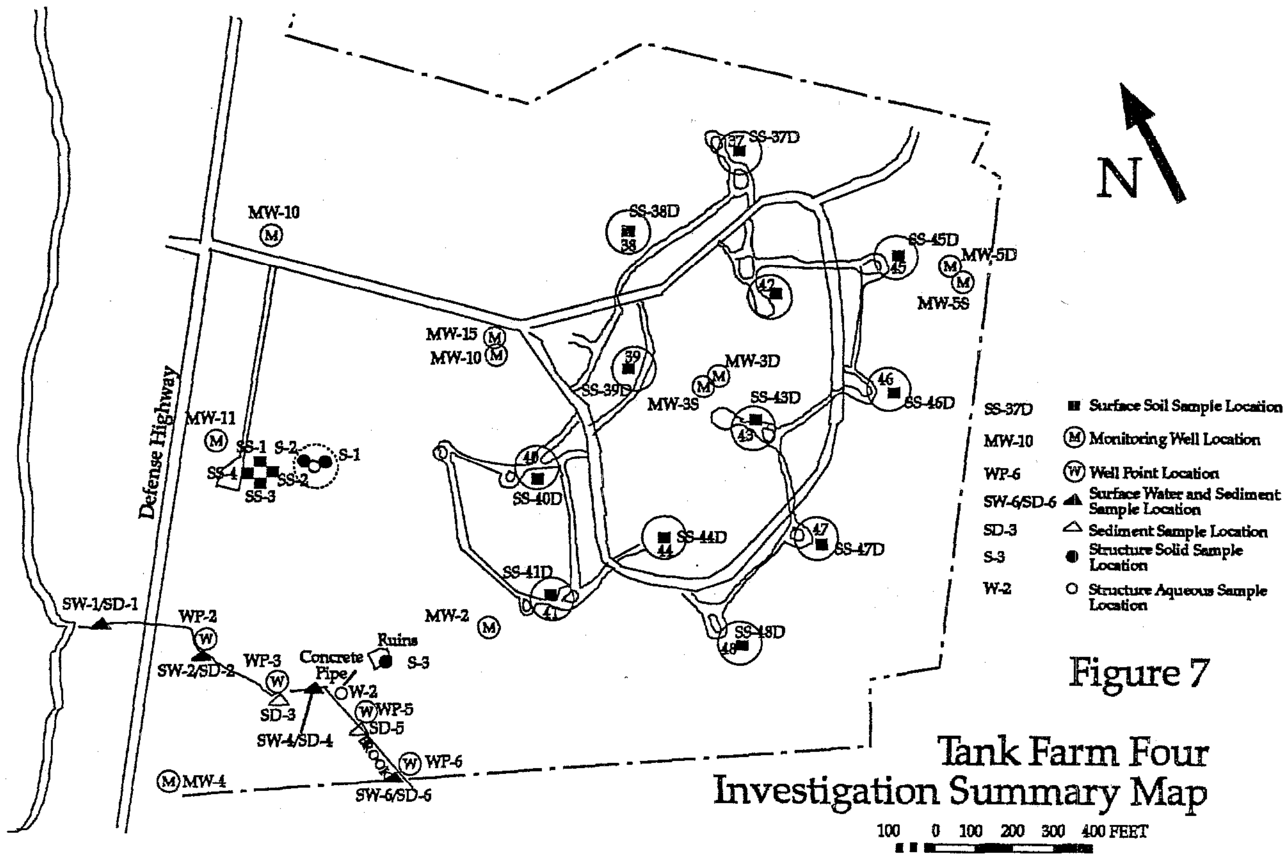


Figure 7

Tank Farm Four
Investigation Summary Map

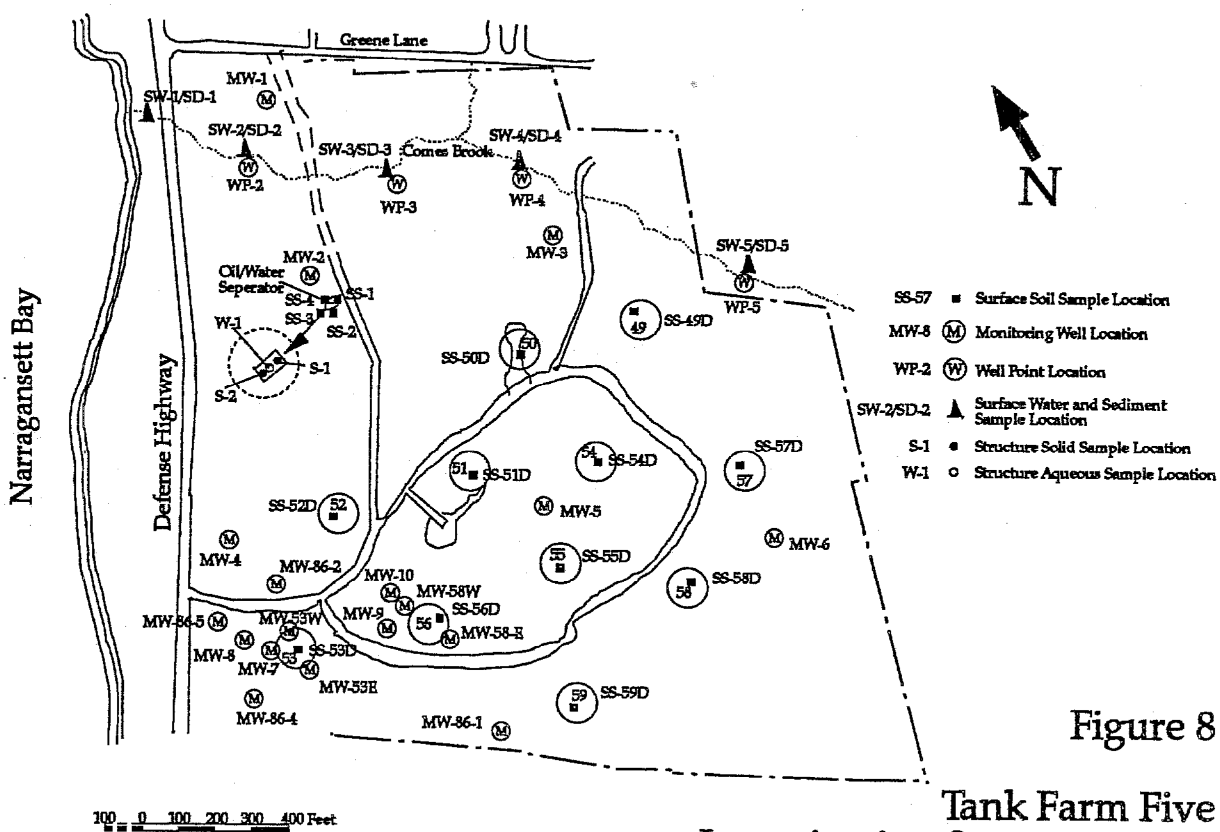


Figure 8

Tank Farm Five
Investigation Summary Map

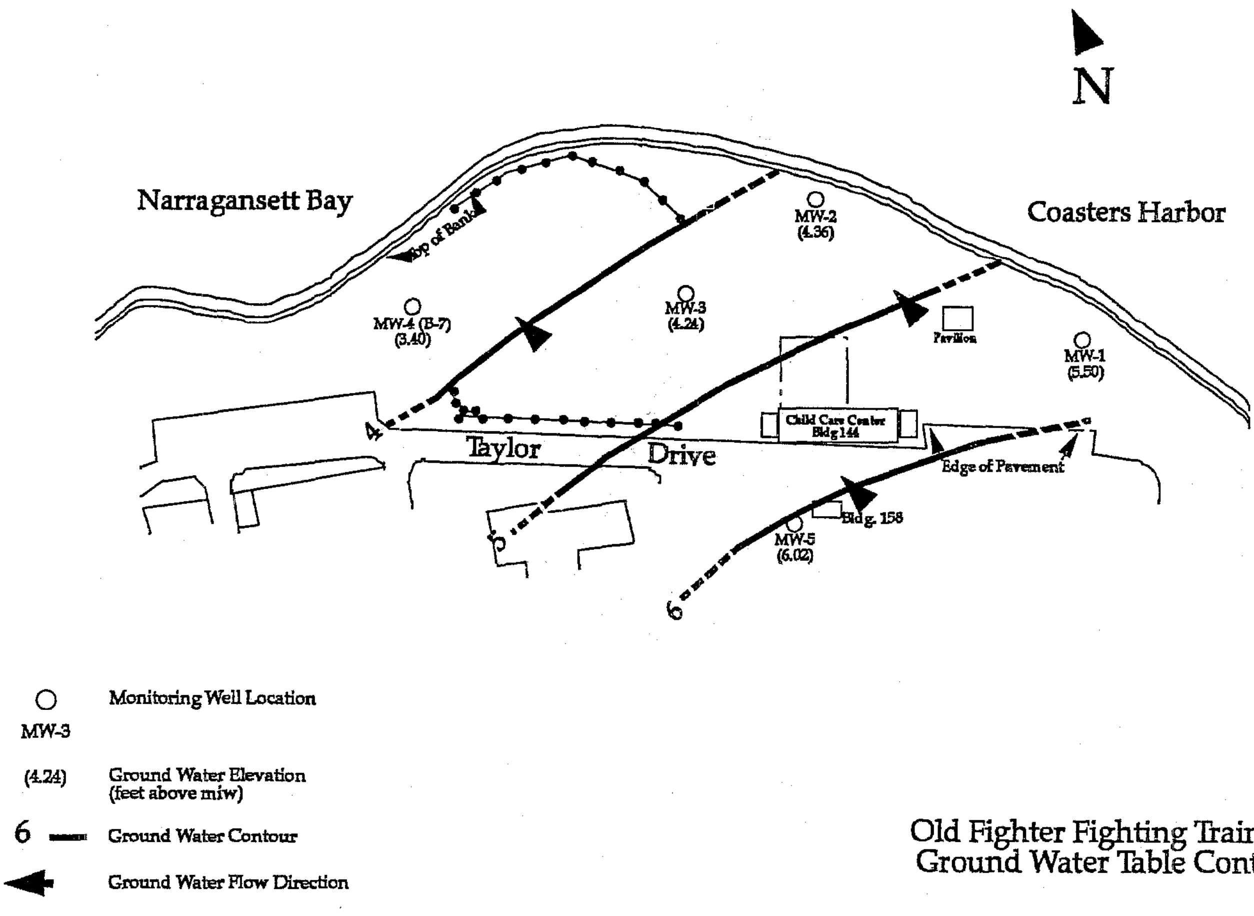
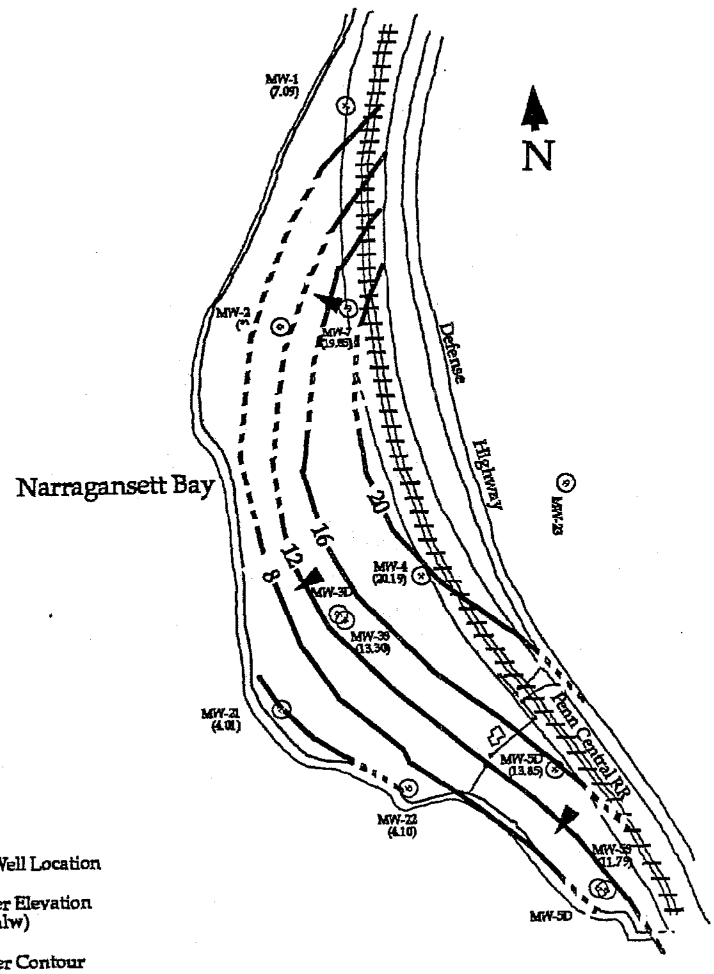


Figure 9

Old Fighter Fighting Training Area
Ground Water Table Contour Map



Monitoring Well Location

MW-1 Ground Water Elevation
(7.09) (feet above mlw)

8 Ground Water Contour

Ground Flow Direction

(*) Note: Well MW-2 Dry on Date of Water Level Measurement

60 0 60 120 180 240 FEET

Figure 10
McAllister Point Landfill
Ground Water Table Contour Map

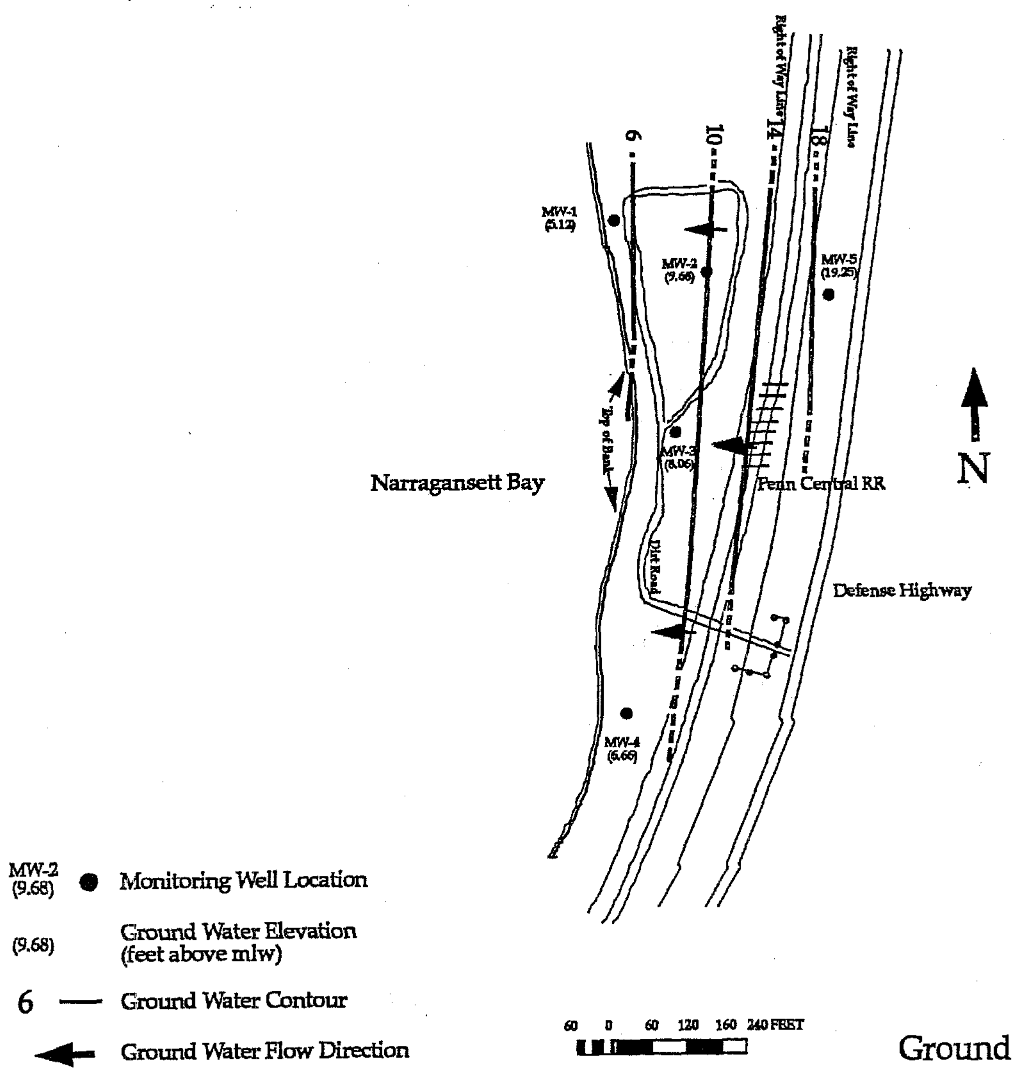


Figure 11

Melville Landfill
Ground Water Table Contour Map

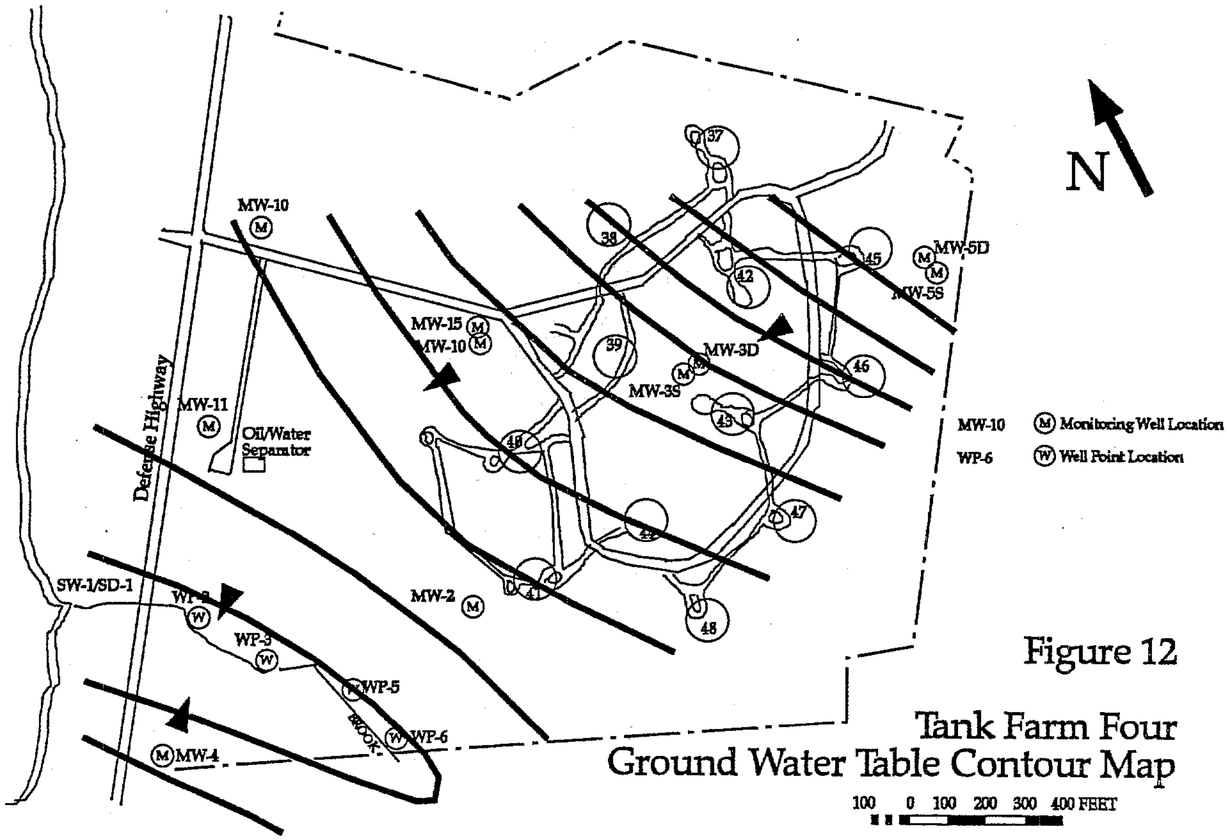


Figure 12

Tank Farm Four
Ground Water Table Contour Map

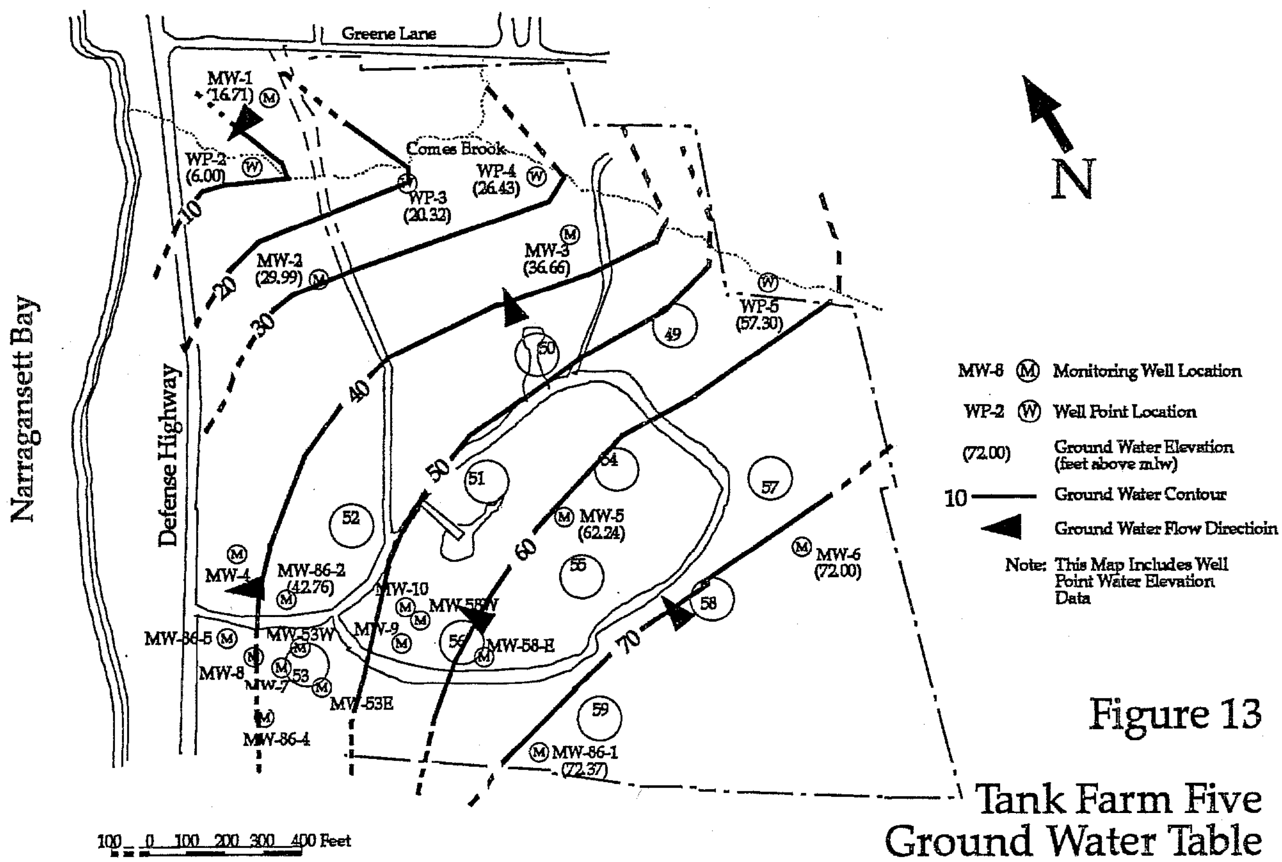


Figure 13

Tank Farm Five
Ground Water Table
Contour Map

APPENDIX B

Chemical-Specific Toxicologic Information

Antimony

Antimony occurs naturally in the earth's crust. A survey by the U.S. Geological Survey of soils throughout the United States showed that antimony concentrations ranged from less than 1 to 8.8 ppm; the average concentration in U.S. soils is 0.48 ppm (1). Antimony does not typically appear in ambient waters (1).

The general population is exposed to low levels of antimony in ambient air and food. Average daily intake from ingestion of food and water has been estimated to be 5-100 μg/day (1).

Quantitative information on absorption of antimony is not available for all chemical forms. However, the International Commission on Radiological Protection (ICRP) has recommended 10% for antimony tartrate and 1% for all other forms of antimony as reference values for gastrointestinal absorption in people (1).

Antimony has several beneficial uses. Antimony and its compounds are currently used to treat two parasitic diseases, schistosomiasis and leishmaniasis. Toxic side effects in people following treatment (injection) with antimony-containing drugs have been reported. Those effects include altered EKG, anemia, vomiting, diarrhea, joint and muscle pain, and death. Altered EKG readings were observed after 4 days of trivalent antimony treatment (0.98mg/kg/day); however, the changes were not observed until after 3 weeks of pentavalent antimony injections (7.2 mg/kg/day) (1). Treatments as low as 0.529 mg/kg day have resulted in vomiting. Antimony may be lethal at very high concentrations. Acute exposure to 2 mg/kg/day stibocaptate (a drug used to treat parasitic disease) caused the deaths of an adult and a child (1). There are no reports of effects in people dermally exposed to antimony.

ATSDR found no information on the carcinogenic potential of antimony in people. However, antimony has not caused cancer in rats or mice exposed by the oral route.

Reference

1. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Antimony. Atlanta: ATSDR, February 1991.

Arsenic

Arsenic is ubiquitous in the environment. It is released into the air by volcanoes, weathering of arsenic-containing minerals and ores, and commercial or industrial processes. Arsenic exists in three common valence states (metalloid, arsenite, and arsenate) and in many different inorganic and organic compounds. Those compounds vary in their toxicity depending on the valence state, physical state (gas, solution, or powder), solubility, rates of absorption and elimination, and presence of impurities. Usually, organic arsenicals are less toxic than inorganic forms. Organic arsenicals that accumulate in fish and shellfish are called "fish arsenic." Those forms (mainly arsenobetaine and arsenocholine) have been found to be essentially nontoxic (1) and are rapidly excreted in urine (2).

Evaluation of arsenic toxicity is complicated because arsenic can exist in several different forms. An additional complexity is that laboratory animals are not good models for arsenic toxicity in humans; animals appear to be less susceptible to arsenic's toxic effects (1).

In humans, chronic oral doses below 1 μg/kg/day are not likely to cause adverse noncancer health effects (1). In the general population, the main route of arsenic exposure is by ingestion of arsenic-contaminated food and water. The average dietary intake of arsenic by adults in the United States has been estimated to be 50 μg/day (range 8-104 μg/day) (2). Soluble forms of arsenic are well absorbed from the gastrointestinal tract (60-90%). Absorption by inhalation has not been determined, but is also believed to be within that range. Dermal absorption is generally negligible; however, effects from dermal absorption have been reported in occupational settings.

The effects of oral exposure to arsenic most likely to be of human health concern are gastrointestinal irritation, peripheral neuropathy, vascular lesions, anemia, skin diseases, and skin cancer. Most noncancer effects are observed at chronic exposures ranging from 0.01 to 0.1 mg/kg/day, and at intermediate exposures ranging from 0.05 to 0.5 mg/kg/day (1). Estimates of the minimum lethal oral dose in humans range from 1 to 3 mg/kg/day (1). Increased risk of cancer is the effect of greatest public health concern related to arsenic exposure by inhalation. Other effects, such as respiratory irritation, nausea, and skin problems, may also occur, but are unlikely below a concentration of 0.1-1.0 mg/m^3 (1).

Chronic gastrointestinal effects are seen predominately after arsenic ingestion. Increased permeability of the small blood vessels, leading to fluid loss and hypotension, is the primary gastrointestinal effect. Other effects include inflammation and necrosis of the mucosa and submucosa of the stomach and intestine (2). Damage to the mucosa may lead to nausea, vomiting, and diarrhea.

Peripheral neuropathy is a common complication of arsenic poisoning. It is predominantly caused by the destruction of axonal cylinders (axonopathy). The neuropathy evolves into a sensorimotor distal axonopathy (2). The neuropathy is usually detected first as a numbness in the hands and feet, but may progress to a painful "pins and needles" sensation (1). More advanced symptoms include weakness, loss of reflexes, and wrist-or ankle-drop. Those effects may diminish after exposure ceases, but recovery is slow and usually not complete (1).

Several studies indicate that arsenic may affect the cardiovascular system (1). Myocardial depolarization and cardiac arrhythmias are characteristic effects of acute and chronic exposure. Chronic exposures may also damage the vascular system. In Taiwan, drinking water levels of arsenic (0.17-0.80 ppm) have been associated with "Blackfoot disease," a condition endemic to the area. The disease is characterized by a loss of circulation in the hands and feet. However, exposure to arsenic may only be a contributing factor. Research has shown that other factors besides arsenic may play a role in the development of the disease. Nevertheless, effects of arsenic exposure on the vascular system have been reported in other populations. In Chile, ingestion of 0.6-0.8 ppm arsenic in drinking water increased the incidence of Raynaud's disease and Crocq's disease (i.e., acrocyanosis; hands and feet are cold, blue, and sweaty). Thickening and vascular occlusion of blood vessels were also observed in persons exposed to arsenical pesticides in Germany.

Anemia and leukopenia are common effects of chronic arsenic poisoning in people. Anemia may be normocytic or macrocytic. A reversible bone marrow depression that initially manifests as pancytopenia could result from arsenic exposure (2). Hematologic effects have not been detected in humans chronically exposed to 0.07 mg/kg/day (1).

Numerous studies in people have reported dermal effects at chronic-dose concentrations ranging from 0.01-0.1 mg/kg/day. The skin lesions most often include hyperpigmentation interspersed with small areas of hypopigmentation on the face, neck, and back, and hyperkeratosis with formation of warts on the palms and soles.

In people, chronic inorganic arsenic ingestion is strongly associated with an increased risk of skin cancer, and may cause cancers of the lung, liver, bladder, kidney, and colon (2). Lung cancer has been linked with chronic inhalation of arsenicals. EPA and the U.S. Public Health Service have classified arsenic as a known human carcinogen (1). The biochemical mechanism of carcinogenicity induced by arsenic is not known. Arsenic does not appear to directly damage DNA, but may inhibit the enzymes involved in DNA replication or repair (1). Computer modeling of epidemiologic data suggests that arsenic acts as a promoter, increasing a late stage in the carcinogenic sequence. Epidemiologic studies indicate that there is a dose-response relationship between the concentration of arsenic in drinking water and the prevalence of skin cancers in the exposed population (2). The most common lesions are multiple squamous cell carcinomas that may develop from hyperkeratotic warts. Multiple basal cell carcinomas may also occur.

There is evidence from studies in people that exposure to inorganic arsenic may increase the risk of cancer. The main carcinogenic effect of oral exposure is increased risk of skin

cancer. However, some studies have indicated that ingestion of arsenic may increase internal tumors, such as liver, kidney, bladder, and lung. Studies in people have noted skin cancer following exposures via drinking water of 0.009 mg/kg/day, and internal tumors at 0.02 mg/kg/day.

In general, most researchers observe that risk of cancer from ingestion of arsenic increases as a function of exposure concentration and duration of exposure (1). Low doses of arsenic may be largely detoxified by methylation (1), producing a nonlinear dose-response curve.

It can be inferred that persons with altered metabolic methylation capacity may be a sensitive population for arsenic exposure. Although there is some evidence that methylation capacity varies among individuals, the basis of that variation and its impact on human susceptibility have not been established.

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1. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Arsenic. Atlanta: ATSDR, February 1992.

2. Agency for Toxic Substances and Disease Registry. Case Studies in Environmental Medicine: Arsenic Toxicity. Atlanta: ATSDR, June 1990.

Barium

Barium is a highly reactive metal that occurs naturally only in a combined state. Barium sulfate and barium carbonate are the forms most often found in soil and water. Barium is not very mobile in most soil systems. The absorption of barium to metal oxides in soils and sediments probably controls its concentration in natural waters.

As are other metals, barium is probably very poorly absorbed from the gastrointestinal tract. Gastrointestinal absorption has been estimated to be less than 5%. Because barium is most commonly encountered in forms with high polarity, it is not expected to cross intact skin. However, some barium may be absorbed in areas of abraded skin. Animal studies indicate that, following inhalation, about 50-65% of barium is deposited in the pulmonary region and eventually absorbed.

Barium compounds vary in their solubilities in water and body fluids and, therefore, behave as variable sources of the Ba^{2+} ion. Ba^{2+} and its soluble forms (barium chloride, barium nitrate, and barium hydroxide) are toxic to humans. The insoluble forms (barium sulfate and carbonate) are generally nontoxic because they are poor sources of the Ba^{2+} ion.

Barium has been associated with a number of adverse health effects in both humans and animals. Evidence suggest that the cardiovascular system may be one of the primary targets of barium toxicity. The most common toxic effects of acute barium exposure in people and animals are increased blood pressure and abnormalities in heart rhythm. Studies have not linked intermediate or chronic ingestion of barium by humans with increased blood pressure, hypertension, stroke, heart disease, or altered electrocardiograms. However, several studies of animals have indicated that intermediate and chronic exposure is associated with adverse cardiovascular effects. Therefore, people with hypertension may be at increased risk if exposed to barium.

Barium repeatedly has been demonstrated to significantly decrease serum potassium in people and animals; therefore, individuals taking diuretics may have a more severe hypokalemic reaction to barium.

Reference

1. Agency for Toxic Substances and Disease Registry. Toxicological Profiles for Barium. Atlanta: ATSDR, February 1991.

Cadmium

Cadmium is a cumulative toxicant. Although urinary excretion is the major mechanism of elimination, it is a slow process, and cadmium's half-life in the body may be up to 30 years (1). For the general population, the exposure of most concern is long-term exposure to elevated levels in the diet. Cadmium intake could be increased as a result of ingestion of cadmium-contaminated dust (on food or hands), garden vegetables or fruit (grown in contaminated soil), and/or water (used for irrigation or drinking). Persons at greatest risk of cadmium exposure are workers in industries producing or using cadmium.

Most ingested cadmium passes through the gastrointestinal tract without being absorbed (1). Nutritional factors affect the amount of cadmium absorbed. Low reserves of calcium, protein, or iron increase cadmium absorption and may increase the risk of toxicity. For example, people with low iron reserves absorb more cadmium than people with adequate iron stores (8.9% and 2.3%, respectively) (1). Diets deficient in calcium stimulate the synthesis of calcium-binding protein, which in turn enhances cadmium absorption (2). Women with low ferritin levels (a protein in the blood that transports iron) have been shown to absorb twice as much cadmium as women with normal serum ferritin levels (2).

Exposure to cadmium by inhalation results in greater absorption. Between 50% and 100% of cadmium deposited in the alveoli will be absorbed (1). As a result, cigarette smoke could add to the amount of cadmium that accumulates in the body (body burden). People who smoke one pack of cigarettes per day typically have cadmium body burdens twice those of nonsmokers.

Renal dysfunction is considered the primary toxic effect of chronic cadmium exposure (1). Impaired tubular reabsorption of filtered solutes (i.e., damage to the renal tubules) is the first manifestation of kidney damage. Elevated incidence of tubular proteinuria have been found in several epidemiologic studies of residents of cadmium-contaminated areas (1). Effects have been seen at exposure doses as low as 0.0021 mg/kg/day.

Tubular dysfunction generally develops only after cadmium reaches a minimum threshold level in the renal cortex (1). The critical concentration in an adult human population chronically exposed to cadmium has been estimated to be about 200 μg/g wet weight in the renal cortex (1). However, a recent large-scale epidemiologic study in Belgium suggests that the critical concentration may be lower (approximately 50 μg/g wet weight) in the general population. Nogawa et al determined (based on cadmium ingestion) that a total intake of approximately 2,000 mg cadmium is the lifetime threshold for proteinuria (renal tubular damage). Proteinuria appears to be irreversible (does not decrease when cadmium exposure stops).

Renal dysfunction can result from either inhalation or oral exposure to cadmium. Kidney damage -- progressing from mild tubular lesions to widespread necrosis, depending on dose -- can be demonstrated following parenteral administration of cadmium to animals. Decreased bone density, particularly in elderly women, may be a significant adverse effect of cadmium accumulation in the kidney. Skeletal effects appear to be secondary to increased urinary calcium and phosphorus losses (3). Evidence suggests that cadmium exposure may affect kidney vitamin D metabolism, resulting in disturbances in calcium balance and bone density. Those effects could lead to osteoporosis or osteomalacia (itai-itai disease). Osteoporosis is a condition characterized by reduction in the quantity of bone or atrophy of skeletal tissue. Osteomalacia is a disease characterized by a gradual softening of the bones and pain as a result of the lack of calcification.

Populations with a genetically determined lower metallothionein inducibility would be more susceptible to renal cadmium toxicity. The sensitivity of the kidney is related to the metabolism of cadmium (1). Cadmium is bound to metallothionein in the body. The kidney filters the metallothionein-cadmium complex from the blood at the glomerulus and reabsorbs it in the proximal tubule. Enzymes in the tubular cells free the cadmium from the complex. Tubular cell metallothionein synthesis is stimulated, but when the cadmium content exceeds 200 $\mu g/g$ wet weight, the free cadmium becomes high enough to cause tubular damage. Free cadmium ions may inactivate metal-dependent enzymes, activate calmodulin, and/or damage cell membranes.

Chronic inhalation of cadmium could impair pulmonary function. Those changes appear after renal damage. EPA and IARC have classified cadmium as a probable human carcinogen when inhaled. Carcinogenic effects of inhalation exposure have been shown in animals; evidence of carcinogenicity in people is less conclusive. No clinical or experimental evidence indicates that ingesting cadmium causes cancer. Other chronic exposure effects may include mild anemia, anosmia, yellowing of teeth, and, occasionally, liver damage. Anemia induced by cadmium exposure is likely to be caused by reduced iron absorption and is unlikely to be of concern in the general population. Liver damage is unlikely because the liver can synthesize metallothionein to sequester the accumulated cadmium.

References

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2. Amdur MO, Doull J, and Klaassen CD. Casarett and Doull's Toxicology: The Basic Science of Poisons. New York: Pergamon Press, 1991.

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Chromium

Chromium is a naturally occurring element found in the environment in several forms. The most common forms are chromium(0), chromium(III), and chromium(VI). Chromium(III) occurs naturally; chromium(0) and chromium(VI) are generally produced by industrial processes.

In soil, when anaerobic conditions exist, chromium(VI) is reduced to chromium (III) by the S^{-2} and Fe^{+2} in soil. The reduction of chromium (VI) to chromium(III) also is possible in aerobic soils that contain appropriate organic energy sources to carry out the redox reaction. In most soils, chromium is present predominantly in the chromium(III) state.

Chromium(III) is an essential element that plays a role in the metabolism of glucose, fat, and protein by enhancing insulin action. A chromium-deficient diet could result in weight loss or decreased growth, improper function of the nervous system, and/or a diabetic-like condition. However, dietary chromium deficiency is relatively uncommon. On the average, adults in the United States take in 25-224 μg/day (average: 75 μg/day). The recommended daily intake for adults is 50-200 μg/day.

Approximately 0.5-2.0% of chromium is absorbed via the gastrointestinal tract. Chromium(VI) compounds are reduced to chromium(III) compounds in the stomach, thereby reducing gastrointestinal absorption of the more toxic element. Both chromium(III) and chromium(VI) can be absorbed through the skin to some extent; dermal absorption is influenced by the carrier medium (air, water or soil contaminated with chromium).

Chromium(VI) is a powerful oxidizing agent; therefore, exposure can cause irritating and corrosive effects. Severe dermatitis and skin ulcers can result from exposure to chromium(VI) salts. On broken skin, skin contact may result in penetrating ulcers known as chrome sores or chrome holes. The progression to ulceration is generally painless, suggesting toxicity to peripheral sensory nerves. Chromium compounds are sensitizers. An allergic dermatitis may develop from exposure to chromium, especially chromium(VI). Chromium(VI) crosses the cell membrane and is metabolized in the cell to chromium(III). A chromium(III)-protein complex may be responsible for the allergic reaction (i.e., chromium(III) may act as the hapten). Also, some sensitive individuals may develop asthma as an anaphylactic response to inhaled chromium.

EPA and IARC have classified inhaled chromium(VI) as a known human carcinogen. Chromium(III) has not been classified as a human carcinogen. Lung cancer is a potential long-term effect of chronic chromium(VI) exposure by inhalation. People who have developed lung cancer after chromium exposure were workers who had significant inhalation exposure for 2 or more years. Chromium-induced lung cancer may take longer than 20 years to develop. Cigarette smoke can act synergistically with chromium exposure to increase the risk of lung cancer. No cancer effects associated with ingestion of or skin contact with chromium have been reported in humans.

References

1. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Chromium. Atlanta: ATSDR, February 1992.

2. Agency for Toxic Substances and Disease Registry. Case Studies in Environmental medicine: Chromium Toxicity. Atlanta: ATSDR, 1990.

Copper

Copper is a naturally occurring metal in rock, soil, water, sediment, and air. The average concentration in soil is about 50 ppm (range 2-250 ppm). Copper occurs in two valence states, copper(I) and copper(II). The biologic availability and toxicity is probably related to copper(II) ion activity. Copper is an essential nutrient; many enzymes require copper for normal function. The National Academy of Science has recommended that 2-3 mg/day (0.03-0.04 mg/kg/day) is a safe and adequate dietary intake for adults.

Copper is readily absorbed from the stomach and small intestine. Copper homeostasis is maintained by the intestinal barrier and liver. Once copper requirements are met, several mechanisms prevent copper overload. In the intestinal mucosal cells, excess copper is bound by metallothionein and other binding proteins. Metallothionein-bound copper can be slowly released to the blood or excreted when the cell is sloughed off. Because the body can prevent absorption of excess copper from ingested sources, the more likely route of entry of toxic copper concentrations would be inhalation or dermal absorption. Absorbed copper binds to plasma proteins and amino acids in the blood. The liver, a second line of defense, incorporates copper into the bile; it is then excreted in the feces.

The most important example of copper toxicity to people is Wilson's disease, an autosomal recessive disorder. The disease is characterized by impaired copper metabolism and increased tissue concentrations of copper. The systemic evidence of disease includes hepatic and renal lesions and hemolytic anemia. Basal ganglia degeneration has also been observed in people with Wilson's disease. Individuals with the disease are unusually susceptible to copper toxicity. People with the disorder must limit copper intake. In healthy individuals, exposure to high concentrations of copper can mimic the effects of Wilson's disease. Also, persons with inherited deficiency of the enzyme glucose-6-phosphate dehydrogenase are likely to be susceptible to toxic effects of oxidative stressors such as copper. Another population at high risk for copper toxicity is children younger than 1 year; they have not developed protective mechanisms for clearing copper from the body and preventing its entry through the intestine.

Little information is available on toxicity of copper in people. Consumption of drinking water with 2.2-3.4 mg/L of copper resulted in liver damage in infants exposed for about 9 months. The infants had pronounced hepatosplenomegaly and increased liver enzymes. Liver biopsy revealed micronodular cirrhosis. No effects were seen in older children or adults exposed to the same water. Vomiting and abdominal pain have been observed in individuals who consumed water containing 7.8 ppm (0.056 mg/kg/day) copper for approximately 1.5 years. Decreased hemoglobin and erythrocytes levels have been seen in workers exposed to airborne copper concentrations of 0.64-1.05 mg/m^3. However, the workers were also exposed to iron, lead, and cadmium, and those agents all affect hemoglobin and erythrocytes.

References

1. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Copper. Atlanta: ATSDR, February 1992.

Lead

Human exposure to lead above baseline levels is common. Environmental lead exposures are related to residence in an urban environment; residence near stationary emission sources; occupation; renovation of homes containing lead paint; and smoking. For the general population, exposure to lead occurs primarily via the oral route; occupational exposure is primarily by inhalation.

Lead toxicity greatly depends on the route of exposure. Lead must be absorbed into the body to produce toxic effects, and the degree of absorption varies according to the route of exposure. Exposure by inhalation results in the greatest amount of absorption. Once deposited in the lower respiratory tract, lead is almost completely absorbed into the body. Absorption from contaminated sources that are ingested appears to be low; however, gastrointestinal absorption depends on age. Absorption following oral exposure in children is approximately 50% compared with 15% in adults (1), partially accounting for the increased sensitivity of children. In general, the skin acts as a barrier to lead absorption. Dermal absorption of inorganic lead compounds is much less significant than absorption by inhalation or ingestion routes of exposure (1). However, organic lead (tetraethyl lead) may be absorbed through the skin. Regardless of the route of exposure, once lead is absorbed into the body, the biologic effects are similar.

The interplay of lead metabolism and the physiologic status of the exposed person, especially nutritional well-being, figure prominently in the level of lead exposure required to produce effects and indications of toxicity. A number of nutritional factors suppress lead absorption and toxicity in humans (3). Iron, calcium, and zinc status are inversely related to lead absorption. Generally, defects in nutrition enhance lead absorption/retention, and therefore, toxicity risk.

Many small exposures to lead can result in chronic toxicity because lead tends to accumulate in body tissues, especially bone. It is the total body burden of lead that is related to toxicity. During pregnancy or in the presence of chronic disease, lead stored in bone tissue can be released and increase concentrations of lead in the blood (1).

Segments of the general population at highest risk of health effects from lead exposure are preschool-age children, pregnant women and their fetuses, and the elderly. Additional groups who may be susceptible to lead exposure are cigarette smokers, alcoholics, and people with nutritional deficiencies, genetic diseases affecting heme synthesis, or kidney or neurologic dysfunction.

The most sensitive target of lead poisoning is the nervous system. Neurologic deficits caused by lead may be irreversible. The developing nervous system in children can be adversely affected at blood lead levels of less than 10 $\mu g/dL$. Effects of lead exposure in children include deficits in IQ score, cognitive function, psychometric intelligence scores, speech and language processing, attention span, hearing acuity, motor skills, reaction time, and hand-eye coordination (2). Central nervous system effects in adults include subtle behavioral changes, fatigue, and impaired concentration. Peripheral nervous system damage is observed, primarily in adults, as a peripheral neuropathy with mild slowing of nerve conduction velocity. Peripheral neuropathies have been observed at blood lead concentrations of 40 μg/dL (2).

Lead has profound adverse effects on human reproduction. Men with blood lead levels greater than 50 μg/dL from occupational exposure had adverse reproductive effects including decreased prostate/seminal vesicle function, lowered semen volumes, and lower functional maturity of sperm (2). An increased likelihood of miscarriage has been associated with occupational lead exposure in pregnant women. Nordstrom et al (1979) found an increased frequency of miscarriages in women living near or working at a lead smelter.

The fetus has no metabolic or anatomic barrier to lead. Lead absorbed by pregnant women can transfer to the fetus via the placenta; therefore, exposure of pregnant women to lead is unsafe. Uptake may occur during the entire pregnancy, including during development of the fetal nervous system and other target organs of lead toxicity. Developmental consequences of prenatal exposure to lead include premature birth, decreased birth weight, and neurobehavioral deficits (3). Maternal blood lead levels of 10 to 15 μg/dL are the levels at which those effects are seen. No relationship was found between prenatal lead exposure and congenital malformations in a prospective study conducted in Port Pirie, South Australia (3).

Exposure to lead could result in adverse hematologic effects. Effects on the blood's biochemical functions are interrelated and have variable biological impact. The lead-associated disturbances in biosynthesis of heme-containing proteins affects several different organ systems (1). Those alterations can 1) disturb the biosynthesis of hemoglobin; 2) reduce the amount of nervous system hemoproteins available for brain cellular energetics and development; 3) disturb the renal heme-mediated generation of the hormonal metabolite of vitamin D (1,25-$(OH)_2$-vitamin D); and 4) impair the ability of heme-dependent liver enzyme systems to adequately detoxify foreign substances.

In addition to the effects on heme biosynthesis, lead has related effects on cellular health and function of the red blood cell, such as enhanced fragility and higher rate of lysis. Lead-induced disturbances in red blood cell formation and maturation also occur by way of alterations in pyrimidine metabolism (3).

The threshold blood lead level for a decrease in hemoglobin is estimated to be 50 μg/dL for adults and 40 μg/dL for children (1). Lead can induce two types of anemia. Hemolytic anemia has been associated with acute, high-concentration lead poisoning. Chronic lead poisoning induces anemia by interfering with erythropoiesis and by diminishing red blood cell survival (2). Anemia is not an early effect of lead poisoning; it is evident only after prolonged periods of significantly elevated blood lead concentrations.

Occupational and general population studies provide strong evidence that a statistically significant association exists between blood lead levels and hypertension (1). The association is most evident in men 40-59 years old and is seen with blood lead levels as low as 7 μg/dL. A mean increase in systolic blood pressure of 1.0-2.0 mmHg appears to result from every doubling in blood lead levels in men 40-59 years old; the increase is somewhat less in adult women.

Qualitative evidence links lead exposure to other cardiac effects, such as degenerative changes in cardiac muscle and electrocardiographic abnormalities. Effects of lead and cadmium on the heart appear to be additive.

EPA has concluded that human data are inadequate to determine the potential carcinogenicity of lead exposure. However, from animal studies, EPA classifies lead as a probable human carcinogen (1). Exposure to lead salts has resulted in kidney tumor development in laboratory animals. Case reports have implicated lead as a potential renal carcinogen in people.

Lead toxicity may be affected by interactions with essential elements and nutrients and other metals. Those interactions may be antagonistic, synergistic, or additive. Chemicals that have been reported to interact with lead include calcium, iron, copper, cadmium, zinc, mercury, vitamin D, ethanol, and phenylhydrazine (1). Mercury, ethanol, and phenylhydrazine increase the toxicity of lead. Calcium, iron, copper, and zinc appear to be antagonistic to the adverse effects of lead. Cadmium has been reported to be antagonistic (enzyme inhibition) and synergistic (lethality and testicular damage).

References

1. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Lead. Atlanta: ATSDR, February 1992.

2. Agency for Toxic Substances and Disease Registry. Case Studies in Environmental Medicine: Lead Toxicity. Atlanta: ATSDR, June 1990.

3. Agency for Toxic Substances and Disease Registry. The Nature and Extent of Lead Poisoning in Children in the United States: A Report to Congress. Atlanta: ATSDR, July 1988.

Manganese

Manganese is a naturally occurring element that exists in the environment primarily as salts or oxide of Mn(+2) or MN(+4). Results of animal studies suggest that people have a nutritional requirement for manganese. The recommended daily intake for an adult is 2.5-5 mg/day (1). The Food and Nutrition Board of the National Research Council has estimated the adequate and safe intake of manganese as 2.5-5 mg/day for adults and 0.7-1.0 mg/day for infants (1).

The amount of manganese absorbed across the gastrointestinal tract in humans is rather variable, but usually averages about 3-5% (1). One of the key determinants of absorption is dietary iron intake. Low iron levels lead to increased manganese absorption.

Although manganese is beneficial at low intake levels, intake of higher levels can cause adverse effects. There is clear evidence that inhalation exposure to manganese dusts in mines and factories can lead to manganism, a neurologic disorder that typically begins with feelings of weakness and lethargy and progresses to a slow and clumsy gait, speech disturbances, a mask-like face, and tremors. The affected person may develop severe hypertonia and muscle rigidity and become permanently disabled. There is only limited evidence that oral exposure to manganese is of concern; however, several individuals have reported similar symptoms after ingesting high levels of manganese (14 mg/L in drinking water). The similarity of the effects seen in the persons who drank manganese-contaminated water with those associated with inhalation exposure suggest that excess manganese intake might lead to neurologic injury. Animal studies have also indicated that oral exposure may lead to neurologic effects. In those studies, a dose of about 980 mg/day was calculated as the neurologic effect level for an adult.

Dermal exposure is not considered to be of health concern -- except to $KMnO_4$, which is corrosive.

Data are not adequate to reach a firm conclusion about the carcinogenicity of manganese, but suggest that the potential for carcinogenic effects in people is small.

Reference

1. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Manganese. Atlanta: ATSDR, February 1991.

Nickel

Nickel is a natural element of the earth's crust; people are regularly exposed to small amounts in food, water, soil, and air. The National Academy of Science does not consider nickel an essential element for people. However, nickel has been shown to be essential for animal health. Nickel deficiency has been induced in several animal species (rats, chicks, goats, cows), indicating that it is an essential element for those species. The average dietary intake of nickel in the United States is 0.002 mg/kg/day. In addition, EPA has stated that long-term exposure to 0.02 mg/kg/day in food or drinking water is safe.

Dermal, inhalation, and oral exposure to nickel has caused adverse health effects in people. The most prevalent effect of dermal exposure to nickel is an allergic contact dermatitis in the general population. Once an individual is sensitized, minimal contact by any route of exposure will elicit a reaction. Studies in sensitized individuals found that the threshold for a response is approximately 0.007 mg/kg/day. About 5% of the general population is sensitive to nickel; women are more sensitive than men, and blacks are more sensitive than whites.

The respiratory system is the target for nickel's toxic effects by inhalation. Both human and animal data suggest that it is unlikely that exposure to nickel in the environment or at hazardous waste sites will result in respiratory effects. No respiratory effects have been observed in people after oral or dermal exposure. Nevertheless, occupational exposure to high concentrations of nickel may result in serious respiratory effects. Effects from occupational exposure to nickel-contaminated dust include chronic bronchitis, emphysema, and reduced vital capacity. However, workers in the studies were also exposed to other toxic metals; therefore, it cannot be concluded that nickel was the sole causative agent of the effects. An intermediate-duration inhalation MRL of 9.0×10^{-6} mg/m^3 was derived from studies of chronic lung inflammation in rats.

The carcinogenic effect of nickel has been well documented in occupationally exposed workers; lung and nasal cancer are the predominant forms. Respiratory cancers are related primarily to exposure to soluble nickel compounds at concentrations greater than 1 mg/m^3, and to exposure to less soluble compounds at concentrations of 10 mg/m^3 or more. There is no evidence that metallic nickel causes respiratory cancer.

The gastrointestinal and hematologic systems may be targets of nickel. EPA has established an oral RfD of 0.02 mg/kg/day for soluble salts of nickel. Generally, the soluble forms of nickel are more toxic than the insoluble forms. Effects reported in workers exposed for one day to nickel in drinking water at 250 ppm (7.1 mg/kg/day) included nausea, cramps, diarrhea, and vomiting. Transient increases in blood reticulocytes and serum bilirubin were also observed in those workers.

References

1. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Nickel. Atlanta: ATSDR, February 1992.

Polychlorinated Biphenyls (PCBs)

PCBs are a family of man-made chemicals containing 209 individual compounds with varying harmful effects (1). There are no known sources of PCBs in the environment. Some commercial PCB mixtures are known by their industrial trade name, Aroclor (1). PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment (1).

Evaluation of the health effects of PCB mixtures (Aroclor) is complicated by several factors, including these: 1) the toxicity of the mixture depends on the toxicity of the individual congeners; 2) the variable degree of contamination with PCDFs (polychlorinated dibenzofurans) increases the toxicity of PCBs; and 3) the PCBs to which people may be exposed are likely to vary from the original PCB source because of environmental changes (1).

Oral exposure through consumption of contaminated food (fish, meat, and animal by-products) is considered to be the major route of exposure to PCB mixtures for the general population (1). Additional sources of exposure for populations near hazardous waste sites are ingestion of and dermal contact with contaminated water and soil.

In people, PCBs distribute preferentially to adipose (fat) tissue. For example, PCBs preferentially concentrate in human breast milk because of its fat content. They may then be transferred to a breast-feeding child via the milk. The higher chlorinated PCBs are the most persistent in fat tissue (preferential bioaccumulation of the metabolism-resistant congeners) (1).

Interaction of PCBs with other chemicals is related to the capacity of PCBs for enzyme induction. The capacity of PCB mixtures to induce cytochrome P-450 has resulted in the modification of toxicity of several chemicals, including solvents, PAHs, and pesticides (1).

Epidemiologic studies of Aroclor-exposed workers (by inhalation and dermal exposures) indicate that the liver, skin, and thyroid may be target organs of PCBs (2). Occupational studies suggest that exposure to PCB mixtures may increase the incidence of liver and gastrointestinal cancer (2). Oral carcinogenicity studies in rats and mice indicate that Aroclor 1254 and Aroclor 1260 are hepatocarcinogens (1). Highly chlorinated PCB mixtures (Aroclor 1260) appear to be more potent than less-chlorinated PCB mixtures (Aroclor 1254). PCBs have been classified as probable human carcinogens by IARC and EPA (1).

Chloracne, erythema, and skin rashes have been reported in people dermally exposed to PCB mixtures. Exposures were estimated to be in the range of 0.026-0.364 mg/kg/day (1).

Two U.S. studies, in which exposure to PCBs was assumed to have been by consumption of contaminated fish, suggest that exposure to PCBs causes developmental effects in people (1). Both studies reported neurodevelopmental effects manifested as motor deficits at birth; impaired psychomotor index (during first year); impaired visual recognition memory (7 months of age); and deficits in short-term memory (4 years of age). Experimental evidence in animals and epidemiologic evidence in people indicates that exposure *in utero* and through breast milk may lead to neurobehavioral deficits in offspring. It is not known if those effects are irreversible.

Populations susceptible to PCB exposure include those with alterations in metabolic capability. Persons exposed to liver enzyme inducers, such as pharmaceutical drugs, tobacco smoke, or alcohol may be more susceptible to exposure. Embryos, fetuses, and neonates have underdeveloped enzymatic systems for chemical elimination that may result in accumulation of PCBs and result in increased toxicity. Populations with altered glucuronide detoxification mechanisms, such as breast-fed infants and individuals with Gilbert's syndrome or Crigler and Najjar syndrome, also are more susceptible to PCBs (1).

References

1. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Polychlorinated Biphenyls. Atlanta: ATSDR, February 1992.

2. Agency for Toxic Substances and Disease Registry. Case Studies in Environmental Medicine: Polychlorinated Biphenyl (PCB) Toxicity. Atlanta: ATSDR, June 1990.

Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) can be man-made or may occur naturally. Man-made sources include the incomplete combustion of organic substances such as coal, oil and gas, and garbage. Natural sources include volcanoes, forest fires, crude oil, and shale oil. Because of the ubiquitous nature of PAHs in the environment, and because most PAHs do not appear alone in the environment, people are rarely exposed to a single PAH. Therefore, discussion of exposure to PAHs as complex mixtures (exposure to more than one PAH) is most representative of real-life situations. Some of the more common PAHs include benzo(a)pyrene, benzo(e)pyrene, benz(a)anthracene, chrysene, pyrene, benzo(k)fluoranthene, and dibenz(a,h)anthracene.

Cancer is the most important endpoint of toxicity resulting from exposure to PAHs (2). Evidence of carcinogenicity in people comes primarily from occupational studies. Cancer associated with exposure of workers to mixtures containing PAHs (e.g., coal tar, roofing tar, soot, coke oven emissions, and crude oil) occurs predominantly in the lung and skin following inhalation and dermal exposure, respectively. Because of the complexity of the mixtures, however, PAHs have not been clearly identified as the causative agent. Other cancers associated with PAHs are urologic, gastrointestinal, laryngeal, and pharyngeal.

The toxic response to PAH mixtures may depend on the interaction of the various components (strongly carcinogenic, weakly carcinogenic, and noncarcinogenic PAHs). Therefore, predicting the toxicity of a complex mixture based on knowledge about one of its components may be misleading. However, in animal studies, some specific PAHs (e.g., benzo(a)pyrene, benz(a)anthracene, chrysene, and dibenz(a,h)anthracene) and have been shown to be carcinogenic. Cancers seen in animals include skin, lung, liver, and stomach. From results of animal studies, EPA has classified some PAHs as probable human carcinogens.

In animals, skin tumorigenicity from dermal PAH exposure can be modified by simultaneous exposure to other PAHs or to long straight-chain hydrocarbons such as dodecane. People potentially exposed to significant levels of PAHs should be aware of the increased risk of cancer and the additive effect of cigarette smoke and other toxic agents.

Significant tumor increases have been reported in animals following chronic oral administration of 2.6 mg/kg/day benzo(a)pyrene (1).

PAHs generally have low acute toxicity to humans. Other toxic substances in the complex mixtures, such as hydrogen sulfide, probably cause the acute symptoms. Effects from chronic exposure to PAHs may include chronic bronchitis, dermatitis, cutaneous photosensitization (sensitivity to sunburn), and pilo-sebaceous reactions. PAHs tend to exert their effects on rapidly growing tissues. A few studies in people and animals have indicated that the rapidly proliferating gastrointestinal, hematopoietic, reproductive, and lymphoid systems may be susceptible to PAH-induced toxicity.

People, in general, have the capacity to enzymatically convert PAHs to less toxic substances. However, people with altered metabolic ability (increased Phase I enzymes, decreased Phase

II enzymes, or decreased efficiency of DNA repair) may have an increased susceptibility to the toxic effects of PAHs. Because of a decreased liver enzyme-conjugating function, the fetus is among the susceptible groups. Persons with deficiencies in vitamins A and C, iron, and riboflavin may also be at increased risk of effects of PAHs. Smoking and excessive exposure to ultraviolet radiation (sunlight) are other factors that may result in increased sensitivity to PAHs.

References

1. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Polynuclear Aromatic Hydrocarbons (PAH). Atlanta: ATSDR, December 1990.

2. Agency for Toxic Substances and Disease Registry. Case Studies in Environmental Medicine: Polynuclear Aromatic Hydrocarbon (PAH) Toxicity. Atlanta: ATSDR, June 1990.

Silver

Silver is a naturally occurring, but rare, element in the environment. Studies in people and animals indicate that silver compounds are absorbed readily from inhalation and oral exposure and poorly from dermal exposure.

Most of the information on the effects of silver in people comes from cases of individuals who have intentionally ingested medicinal silver compounds, and from exposures of workers in chemical manufacturing industries. The one clinical condition in people known to be associated with long-term exposure to silver compounds is an irreversible gray or blue-gray discoloring of the skin (argyria). The condition may be limited to a specific area of the skin that has repeated dermal contact with silver or silver compounds. Following chronic oral or inhalation exposure, it also may occur over widespread areas of the skin and include the conjunctiva of the eyes. The pigmentation is not a toxic effect per se, nor is it known to be diagnostic of any other toxic effect. However, the discoloration can be severe enough to be considered a cosmetic disfigurement. No good quantitative correlations have been drawn between body burdens of silver and observed effects. Hill and Pillsbury (1939) reported that the condition may result from total doses of silver as low as 1.4 grams ingested in small, unspecified doses over several months.

Human and animal studies have provided evidence that inhalation of silver compounds can irritate the respiratory tract. Occupational studies and reports of accidental ingestion of silver compounds have shown that both inhalation and ingestion may cause gastric irritation. However, those effects are likely to be related to the caustic properties of the compounds, and not to the presence of silver. The effects are not expected to persist when exposure has stopped. Human occupational and animal toxicity studies have not indicated carcinogenicity; therefore, silver is not expected to be carcinogenic in humans.

References

1. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Silver. Atlanta: ATSDR, December 1990.

Vanadium

Vanadium is a naturally occurring element in the soil; the average content in U.S. soils is 200 mg/kg. It occurs naturally in fuel oils and coal. In the body, vanadium exists in two oxidation states, the tetravalent form (vanadyl) and the pentavalent form (vanadate).

The one clearly documented adverse health effect in people is respiratory distress after inhalation of large amounts of vanadium dusts. The symptoms include coughing, chest pains, sore throats, and irritated eyes -- effects that are common to many types of dust exposure. Symptoms are reversible within days or weeks after exposure stops. For most people to be at risk, large amounts of vanadium dusts would have to be present at the point of exposure. No other significant health effects of vanadium have been found. Dermal and gastrointestinal absorption are low in people. Therefore, risk of toxicity from such exposures may be low.

An acute MRL of 0.006 mg/m^3 in air was derived from human data. An MRL of 0.003 mg/kg/day was derived from animal data (exposed via water) for intermediate exposure.

References

1. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Vanadium. Atlanta: ATSDR, February 1991.

Zinc

Zinc is ubiquitous in the environment; therefore, people are exposed daily through food, water, and air. Zinc is also an essential nutrient required for good health. The recommended dietary allowance is 15 mg/day (0.21 mg/kg/day) for men and 12 mg/day for women. Extra dietary amounts are recommended for women during pregnancy and lactation; lower intake is recommended for infants and children.

About 20-30% of ingested zinc is absorbed. Several factors, such as existing nutritional status and type of food eaten, can influence absorption. Metallothionein, a metal-binding protein, may control intestinal transport of zinc. Excess zinc is bound to metallothionein in the mucosal cells and is excreted when the cells are sloughed off.

Zinc concentrations that produce adverse health effects are usually much higher than the recommended dietary allowances. Ingestion of zinc sulfate at 2.3-4.3 mg/kg/day for 5-6 weeks reduced HDL-cholesterol concentrations in humans. In addition, decreases in HDL-cholesterol concentrations have been reported in individuals taking 50 mg/day or 75 mg/day for 6-12 weeks. The presence of HDL-cholesterol has been associated with decreased risk of coronary artery disease. However, there is no evidence of a direct association between excessive zinc intake and cardiac mortality.

References

1. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Zinc. Atlanta: ATSDR, December 1989.

APPENDIX C

State of Rhode Island
Department of Health
Vital Statistics Annual Report
1980, 1985, 1988

Vital Statistics Birth/Death Rate (1980)				
	Rhode Island	**Portsmouth**	**Middletown**	**Newport**
Number of Live Births	12,166	197	259	418
Rate/1000	12.8	13.8	15.0	14.3
Number of Deaths	9,300	103	90	326
Rate/1000	9.8	7.2	5.2	11.1
Number of Deaths by Age Group (Younger than 1)	133	2.0	2.0	4.0
1 - 4	18	0.0	0.0	0.0
5 - 14	41	0.0	0.0	0.0
15 - 24	158	2.0	2.0	2.0
25 - 34	160	0.0	0.0	7.0
35 - 44	196	2.0	2.0	7.0
45 - 54	510	9.0	5.0	14
55 - 64	1,394	13	17	54
Older than 65	6,690	75	62	238
1975 -1980 Infant Deaths	752	7.0	24	33
1975 - 1980 Infant Death Rate	13	6.9	17.6	15.4
1975 -1980 Low Birth Weight	3,823	47	71	169
1975 -1980 Low Birth Weight Rate	66	46.1	52.2	79

Vital Statistics Birth/Death Rate 1985				
	Rhode Island	**Portsmouth**	**Middletown**	**Newport**
Number of Live Births	14,179	208	258	426
Rate/1000	1.43	12.6	14.5	15.4
Number of Deaths	9,724	98	141	252
Rate/1000	9.8	5.9	7.9	9.1
Number of Deaths by Age Group (Younger than 1)	116	0.0	1.0	2.0
1 - 4	14	0.0	0.0	2.0
5 - 14	23	0.0	0.0	1.0
15 - 24	92	2.0	0.0	4.0
25 - 34	182	0.0	4.0	5.0
35 - 44	241	3.0	6.0	4.0
45 - 54	417	3.0	3.0	16
55 - 64	1,169	14	16	21
Older than 65	7,467	76	111	197
1981 - 1985 Infant Deaths	590	6.0	12	21
1981 - 1985 Infant Death Rate	8.8	5.6	9.1	9.9
1981 -1985 Low Birth Weight	4,146	39	77	114
1981 -1985 Low Birth Weight Rate	61.7	36.3	58.3	54.0

Vital Statistics Birth/Death Rate (1988)				
	Rhode Island	Portsmouth	Middletown	Newport
Number of Live Births	12,996	238	263	413
Rate/1000	13.4	15.8	14.9	13.8
Number of Deaths	9,636	118	120	275
Rate/1000	10.0	7.8	6.8	9.2
Number of Deaths by Age Group (Younger than 1)	106	1.0	2.0	4.0
1 - 4	14	0.0	0.0	1.0
5 - 14	26	1.0	1.0	0.0
15 - 24	126	3.0	1.0	6.0
25 - 34	148	3.0	3.0	2.0
35 - 44	205	5.0	5.0	4.0
45 - 54	425	11	4.0	8.0
55 - 64	1,295	17	9.0	44
Older than 65	7,291	77	95	206
1984 - 1988 Infant Deaths	646	8.0	9.0	23
1988 - 1988 Infant Death Rate	10.2	7.2	7.1	11.1
1984 - 1988 Low Birth Weight	3,896	34	69	121
1984 - 1988 Low Birth Weight Rate	61.7	30.7	54.1	58.5

Selected Mortality Data by Town and State (1980)				
	Rhode Island	Middletown	Newport	Portsmouth

All Deaths	9,300	90	326	103
Malignant Neoplasms	2,127	30	89	24
Lung Cancer	481	9	26	6
Female Breast Cancer	184	3	10	2
Cervical Cancer	21	1	1	0
Lip, Oral Cavity, & Pharynx Cancer	59	0	3	0
Diabetes Mellitus	199	0	5	2
Diseases of the Heart	3,831	42	111	45
Cerebrovascular Disease	723	4	25	10
Influenza & Pneumonia	206	2	5	2
Chronic Obstructive Pulmonary Disease	279	0	8	3
Chronic Liver Disease	148	0	10	2
Congenital Anomalies	58	0	1	0
Accidents	328	5	11	1
Suicide	108	1	5	3
Homicide	55	0	2	2

Selected Mortality Data by Town and State (1985)				
	Rhode Island	Middletown	Newport	Portsmouth
All Deaths	9,636	120	275	118
Malignant Neoplasms	2,365	27	64	32
Lung Cancer	595	10	15	12
Female Breast Cancer	230	4	4	4
Cervical Cancer	20	0	0	0
Lip, Oral Cavity, & Pharynx Cancer	45	0	2	0
Diabetes Mellitus	221	6	5	3
Diseases of the Heart	3,684	41	90	40
Cerebrovascular Disease	645	9	21	8
Influenza & Pneumonia	263	2	5	4
Chronic Obstructive Pulmonary Disease	353	5	10	3
Chronic Liver Disease	109	3	2	2
Congenital Anomalies	47	0	0	2
Accidents	264	5	5	8
Suicide	96	1	3	2
Homicide	39	1	2	0

Selected Mortality Data by Town and State (1988)				
	Rhode Island	**Middletown**	**Newport**	**Portsmouth**
All Deaths	9,724	141	252	98
Malignant Neoplasms	2,447	35	58	22
Lung Cancer	629	8	9	5
Female Breast Cancer	236	5	8	0
Cervical Cancer	18	1	0	0
Lip, Oral Cavity, & Pharynx Cancer	63	1	0	0
Diabetes Mellitus	282	4	3	3
Diseases of the Heart	3,488	35	91	35
Cerebrovascular Disease	648	9	15	3
Influenza & Pneumonia	240	9	6	0
Chronic Obstructive Pulmonary Disease	361	8	9	7
Chronic Liver Disease	136	1	6	2
Congenital Anomalies	40	0	0	2
Accidents	280	7	8	1
Suicide	102	0	4	3
Homicide	46	0	2	0